DRAFT

Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

PRE-DESIGN INVESTIGATION PHASE I DATA EVALUATION REPORT FOR THE LOWER DUWAMISH WATERWAY UPPER REACH

DRAFT

For submittal to

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ABBREVIATIONS

AC	activated carbon
ARI	Analytical Resources, Inc.
BBP	butyl benzyl phthalate
BEHP	bis(2-ethylhexyl) phthalate
COC	contaminant of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
DER	Data Evaluation Report
DQO	data quality objective
DRET	dredge elutriate testing
EAA	early action area
Ecology	Washington State Department of Ecology
ENR	enhanced natural recovery
EPA	US Environmental Protection Agency
ESD	explanation of significant differences
FNC	federal navigation channel
FS	feasibility study
GPS	global positioning system
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MHHW	mean higher high water
MLLW	mean lower low water
MNR	monitored natural recovery
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDI	Pre-Design Investigation
QAPP	Quality Assurance Project Plan
QC	quality control
RAA	remedial action area
RAL	remedial action level
RD	remedial design
RDWP	Remedial Design Work Plan
RI	remedial investigation

RM	river mile
ROD	Record of Decision
SCO	sediment cleanup objective
SEF	*Sediment Evaluation Framework for the Pacific Northwest*
SMS	Washington State Sediment Management Standards
SVOC	semivolatile organic compound
T-117	Terminal 117
TEQ	toxic equivalent
TOC	total organic carbon
UCT-KED	universal cell technology-kinetic energy discrimination
USACE	US Army Corps of Engineers

1 Introduction

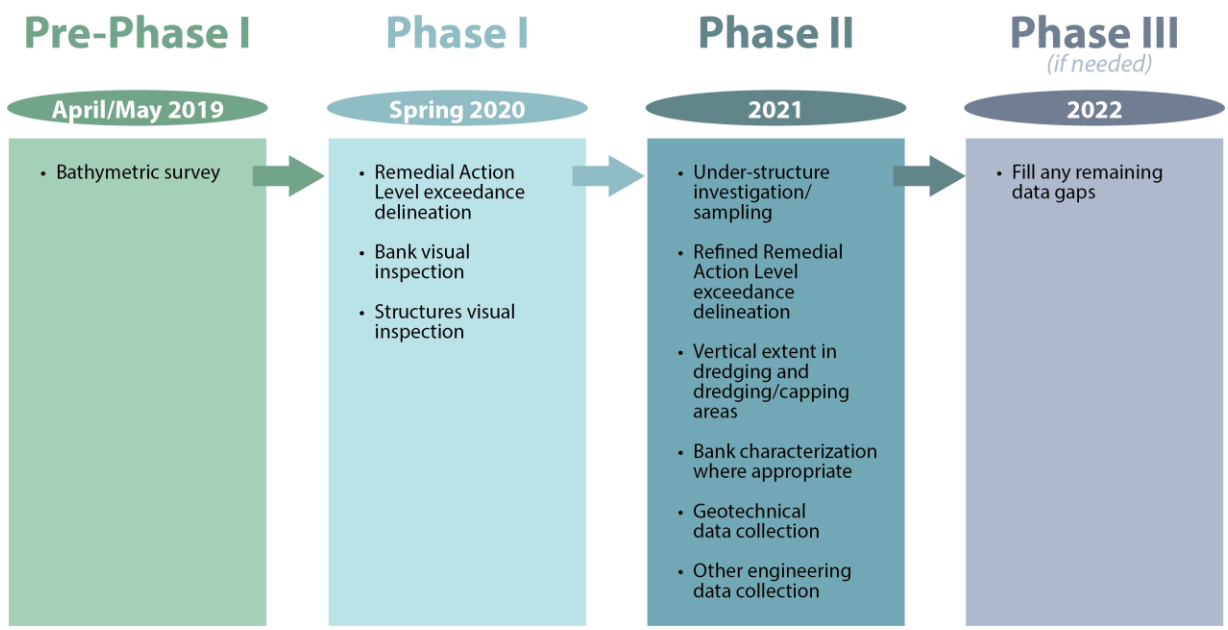
This document is the Phase I Data Evaluation Report (DER) in support of remedial design (RD) for the upper reach (river mile [RM] 3.0 to RM 5.0) of the Lower Duwamish Waterway (LDW) Superfund site in King County, Washington. Per the fourth amendment to the Administrative Order on Consent, the Phase I DER presents the results of the Phase I Pre-Design Investigation (PDI), defines areas with exceedances of the remedial action levels (RALs),[1] lists preliminary technology assignment options for these areas, and identifies data gaps for the Phase II PDI. These data gaps will be addressed through a Phase II Addendum to the PDI Quality Assurance Project Plan (QAPP) (Windward and Anchor 2020), herein referred to as the QAPP Addendum. This Phase I DER was prepared on behalf of the City of Seattle, King County, the Port of Seattle, and The Boeing Company, collectively referred to as the Lower Duwamish Waterway Group (LDWG).

1.1 Phase I Data Evaluation Report Objectives

Per the remedial design work plan (RDWP) (Anchor and Windward 2019a), design sampling is being done in phases (Figure 1-1). Phase I focuses on defining the horizontal extent of RAL exceedance areas and listing technology assignment options in order to identify Phase II PDI data gaps. Phase II will involve the collection of data to further delineate the areas with RAL exceedances in surface sediment (0–10 cm), subsurface sediment (0–45 cm in the intertidal and 0–60 cm in the subtidal), and shoaling areas and assess vertical contaminant extent (i.e., the overall depth of contamination) in dredge or partial dredge and cap areas. Phase II will also involve collection of characterization data in bank areas that are within areas with RAL exceedances, geotechnical data, and area-specific engineering data needed for RD. Phase III will be conducted if data gaps remain after Phase II.

[1] RALs are defined in Table 28, titled *Remedial Action Levels, ENR Upper Limits, and Areas and Depths of Application*, of the US Environmental Protection Agency's (EPA's) November 2014 Record of Decision (ROD) (EPA 2014). As stated in the ROD, a RAL is a contaminant concentration above which remedial action is required.

Figure 1-1
Design Sampling Phases



Per the RDWP and Pre-Design Investigation Work Plan (Windward and Anchor 2019; Anchor and Windward 2019a), this Phase I DER meets the following objectives in the overall design process.

- Summarize the results of the Phase I PDI, including results from the sediment chemistry analyses (Tiers 1, 2, and 3), bank visual inspection, and structures visual inspection.
- Define preliminary areas with RAL exceedances.
- Identify preliminary technology assignment options for each area with RAL exceedances consistent with the decision trees in the ROD (Figure 19 and updated Figure 20 of the ROD).
- Discuss any revisions to recovery categories based on additional Phase I bathymetry data collected in 2020 and contaminant trend analysis.
- Identify Phase II data gaps to set the stage for the QAPP Addendum.
- Provide a Phase I PDI bathymetric data gaps survey data report with methods, deviations, and data.

The preliminary areas with RAL exceedances presented in this Phase I DER will be updated with Phase II data and refined in the Phase II DER using a final interpolation method. Based on these areas and other engineering considerations, remedial action areas (RAAs) will be defined at 30% design

and then refined and grouped into sediment management areas at 60% design, as discussed in the RDWP (Table 1-1).

Table 1-1
Areas to be Defined During the RD Process

Area	Definition	Where Defined
RAL exceedance area	Area where RAL is exceeded by at least one contaminant based on comparison of interpolated concentrations to RALs in ROD Table 28	Phase I DER; areas will be refined in the Phase II DER using Phase II data and a final interpolation approach
RAA	Area developed by considering how the selected remedial technologies are constructed and overlaying engineering considerations; RAA boundaries are set at or beyond the final interpolated boundaries of the RAL exceedance areas	30% RD
Sediment management area	Area organized by grouping RAAs by remedial technology, site physical conditions, or operational restrictions	60% RD

Notes:
DER: data evaluation report
RAA: remedial action area
RAL: remedial action level
RD: remedial design
ROD: Record of Decision

The areas with RAL exceedances delineated in this document will likely be different than the RAAs in 30% design, because the RAAs:

- Will be based on a larger design dataset[2] that will include Phase II PDI data
- Will be based on final geostatistical interpolation of the final design dataset using methods described in detail in the Phase II DER
- Will include engineering considerations, such as geotechnical, slope and structural stability, sediment stability, and constructability considerations

1.2 Phase I DQOs

The PDI QAPP (Windward and Anchor 2020) presented data quality objectives (DQOs) for Phase I (Table 1-2). DQOs 1 through 7 were met through Phase I sediment sampling at 266 locations in June 2020; three tiers of chemical analysis at a total of 213 locations, combined with existing sediment data, provided a preliminary horizontal footprint of RAL exceedances. DQO 8 was addressed through visual surveys conducted during a series of low tides in June through August 2020.

[2] The design dataset includes data from the remedial investigation/feasibility study (RI/FS), post-FS data, and PDI data (see Section 3.1).

Table 1-2
DQOs for Phase I PDI in the Upper Reach

Phase I
DQO1 – Delineate 0–10-cm RAL exceedances in Recovery Category 2/3.
DQO2 – Delineate 0–10-cm RAL exceedances in Recovery Category 1.
DQO3 – Delineate 0–45-cm intertidal RAL exceedances in Recovery Category 2/3.
DQO4 – Delineate 0–45-cm intertidal RAL exceedances in Recovery Category 1.
DQO5 – Delineate 0–60-cm PCB RAL exceedances in potential vessel scour areas in Recovery Category 2/3.
DQO6 – Delineate 0–60-cm RAL exceedances in Recovery Category 1.
DQO7 – Delineate RAL exceedances in shoaling areas.
DQO8 – Conduct a visual inspection of the banks in the upper reach to identify features relevant to design, such as the presence/absence of bank armoring, and to plan how to access banks and areas under structures for sampling purposes.

Notes:
DQO: data quality objective
PCB: polychlorinated biphenyl
PDI: Pre-Design Investigation
RAL: remedial action level

Phase II DQOs, as discussed in Section 4, will be met through Phase II sampling in order to fill data gaps identified in this DER. Details of the Phase II sampling will be outlined in the upcoming QAPP Addendum.

1.3 Report Organization

The remainder of this document is organized into the following sections:

- Section 2: Phase I PDI Summary
- Section 3: Data Evaluations
- Section 4: Phase II Data Gaps
- Section 5: Next Steps
- Section 6: References

The following appendices are attached to this document:

- Appendix A: Location Coordinates, Sediment Chemistry Field Notes and Forms, Chain of Custody Forms, and Photographs
- Appendix B: Sediment Chemistry Laboratory and Validation Reports
- Appendix C: Phase I Data File
- Appendix D: Relationship Between Surface and Subsurface Contaminant of Concern (COC) Concentrations
- Appendix E: Bank Visual Inspection Detailed Observations, Photographs, and Videos
- Appendix F: Structures Visual Inspection Forms

- Appendix G: 2020 Bathymetric Survey Data Report
- Appendix H: Data Rules
- Appendix I: Recommended Recovery Category Modifications
- Appendix J: Interpolation Methods for Delineating Areas with RAL Exceedances
- Appendix K: Preliminary Technology Assignment Options for Areas with RAL Exceedances

2 Phase I Pre-Design Investigation Summary

This section presents the sediment data and visual bank and structure inspection results from the Phase I PDI. In combination with existing chemistry data, the sediment sampling results are evaluated in Section 3 to identify preliminary areas with RAL exceedances.

2.1 Sediment Sampling

2.1.1 Field Sampling Overview

In June 2020, sediment samples were collected from 266 locations throughout the upper reach of the LDW (RM 3.0 to RM 5.0) (Map 2-1). Surface sediment grab samples were collected at 249 locations from June 5 through 30, and subsurface sediment cores were collected at 247 locations from June 1 through 26 (Map 2-2). Target and actual sampling coordinates and mudline elevations for the sampling locations (both surface and subsurface) are provided in Appendix A (Maps A-1a through A-1d and A-2a through A-2d and Tables A-1 and A-2, respectively).

Surface grab samples and subsurface sediment cores were collected and processed following the standard operating procedures described in Appendix F of the PDI QAPP (Windward and Anchor 2020). Generally, sediment samples were collected from the target depths using a pneumatic grab sampler (for surface sediment) or a vibracorer (for subsurface cores). Deviations from the PDI QAPP involved modifications to sediment core acceptance criteria at some locations. EPA was notified of all deviations when the samples were collected. These field deviations did not affect the data quality. The core acceptance criteria deviations were as follows:

- The intertidal core from location 127 was accepted with 52.5% (64.0 cm) recovery after hitting refusal during five attempts. EPA approved retaining and processing the core with the best recovery.
- The subtidal core from location 214 was accepted with 74.1% (101.6 cm) recovery after three attempts. EPA approved retaining and processing the core with the best recovery (i.e., third attempt).
- The subtidal core from location 380 was accepted with 49.5 cm of penetration and recovery after hitting refusal at that depth during 12 attempts. The target depth for this location was 60 cm. EPA was consulted and authorized retaining the best core sample while remaining within the targeted Recovery Category 1 boundary.
- Coring was not successful at location 417. The target depth for this location was 45 cm. A reconnaissance of the area during sampling revealed riprap armoring throughout the targeted area. EPA was consulted and authorized manual sample collection (e.g., with a

spoon and bowl) to obtain the sample. The sample for this location was collected from the 0–29-cm depth interval.

- Z-layers (-17 ft to -18 ft mean lower low water [MLLW]) were not collected at subtidal (shoaling) core locations[3] 148 and 201. The cores were driven to refusal at -17 ft MLLW during three attempts at location 148 and seven attempts at location 201.

Field logbooks, field collection and processing forms, chain of custody forms, and photos of surface sediment grab and subsurface sediment core samples are provided in Appendix A.

2.1.2 Laboratory Testing Overview

2.1.2.1 Analytical Methods

The methods and procedures used to chemically analyze the individual and composite sediment samples are described briefly in this section and in detail in the PDI QAPP (Windward and Anchor 2020). This section also discusses laboratory deviations from the PDI QAPP. Laboratory and validation reports are provided in Appendix B. Complete chemistry and grain size data for Phase I are included in Appendix C.

Analytical Resources, Inc. (ARI) performed polychlorinated biphenyl (PCB) Aroclor, carcinogenic polycyclic aromatic hydrocarbon (cPAH), semivolatile organic compound (SVOC), dioxin/furan, arsenic and other metals including mercury, total organic carbon (TOC), and total solids analyses. Harold L. Benny & Associates, LLC performed grain size analysis. Sediment samples were analyzed according to the methods presented in Table 2-1.

Table 2-1
Analytical methods for sediment analyses

Analyte	Method	Reference	Extraction Solvent	Laboratory
PCB Aroclors	Gas chromatography /electron capture detector	EPA 3546 Mod EPA 8082A	Hexane/acetone	ARI
PAHs/SVOCs	Gas chromatography /mass spectrometry	EPA 3546/ EPA 8270E	Dichloromethane /acetone	ARI
cPAHs/SVOCs	Gas chromatography /mass spectrometry	EPA 3546/ EPA 8270E-select ion monitoring	Dichloromethane /acetone	ARI
Hexachlorobenzene	Gas chromatography /electron capture detector	EPA 3546/EPA 8081B	Hexane/ acetone	ARI

[3] Sample depths collected at shoaling locations were defined in Figure 4-1 in the PDI QAPP (Windward and Anchor 2020).

Analyte	Method	Reference	Extraction Solvent	Laboratory
Dioxins/furans	High-resolution gas chromatography/high resolution mass spectrometry	EPA 1613B	80:20 toluene:acetone extraction	ARI
Metals	Inductively coupled plasma-mass spectrometry	EPA 3050B EPA 6020A universal cell technology-kinetic energy discrimination	na	ARI
Mercury	Cold vapor-atomic fluorescence spectrometry	EPA 7471B	na	ARI
TOC	High-temperature combustion	EPA 9060A	na	ARI
Total solids	Drying oven	Standard Method 2540G	na	ARI
Grain size	Pipette/sieve	Puget Sound Estuary Program (1986)	na	Harold L. Benny & Associates, LLC

Notes:
ARI: Analytical Resources, Inc.
cPAH: carcinogenic polycyclic aromatic hydrocarbon
EPA: US Environmental Protection Agency
na: not applicable
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
SVOC: semivolatile organic compound
TOC: total organic carbon

The PDI QAPP organized the upper reach into four segments (Map 2-1). The number of sampling locations in each segment is presented in Table 2-2. Of the 266 sampling locations in the upper reach, 140 were in intertidal areas and 126 were in subtidal areas (Map 2-2). The sediment depth intervals collected at each location were determined in the PDI QAPP based on the bathymetry of the sample location (intertidal, subtidal, or shoaling area) and the recovery category, consistent with ROD Table 28 (Windward and Anchor 2020).

Table 2-2
Summary of Upper Reach Locations Sampled During the Phase I PDI

Segment	Total Locations	No. of Surface Sediment Locations		No. of Subsurface Sediment Locations		
		Intertidal (0–10 cm)	Subtidal (0–10 cm)	Intertidal (0–45 cm)	Subtidal[1] (0–60 cm)	Shoal Cores[2]
Segment 1 (RM 3.0 to RM 3.5)	70	25	41	18	45	7
Segment 2 (RM 3.5 to RM 4.05)	74	28	42	29	11	33
Segment 3 (RM 4.05 to RM 4.81)	94	59	26	56	31	-
Segment 4 (RM 4.81 to RM 5.0)	28	19	9	17	-	-
Total	**266**	**131**	**118**	**120**	**87**	**40**

Notes:
1. The number of 0–60-cm samples does not include shoal cores.
2. Shoal cores were collected in the FNC in Segments 1 and 2. The FNC in Segments 3 and 4 is regularly dredged by the USACE. Sample depths for subsurface samples in shoaling areas varied depending on the depth of the shoal at each location (see PDI QAPP Figure 4-1) (Windward and Anchor 2020). Details for each shoaling location are presented in Appendix A.
FNC: federal navigation channel
PDI: Pre-Design Investigation
QAPP: Quality Assurance Project Plan
RM: river mile
USACE: US Army Corps of Engineers

The number of samples collected and the number analyzed in each segment of the upper reach are presented in Table 2-3. Field duplicates are not included in the sample counts. In general, in the intertidal areas, a surface sediment (0–10-cm) sample and a subsurface intertidal sediment (0–45-cm) sample were collected at each location. In the subtidal areas, in general, a surface sediment (0–10-cm) sample and a subsurface sediment (0–60-cm) sample were collected at each location. In the shoaling areas within the federal navigation channel (FNC), cores were collected to characterize the shoal material above the authorized navigation depth at -15 ft MLLW as well as the 60-cm interval below the authorized depth (between -15 ft MLLW and -17 ft MLLW).

Table 2-3
Summary of Upper Reach Samples Collected and Analyzed for at Least One Analyte During the Phase I PDI

	No. of Samples Collected				No. of Samples Analyzed[1]			
	Surface	Subsurface			Surface	Subsurface		
Segment	0–10 cm	Intertidal (0–45 cm)	Subtidal (0–60 cm)[1]	Shoal intervals[2]	0–10 cm	Intertidal (0–45 cm)	Subtidal (0–60 cm)[2]	Shoal Intervals[3]
Segment 1 (RM 3.0 to RM 3.5)	66	18	45	22	50	10	43	12
Segment 2 (RM 3.5 to RM 4.05)	70	29	11	95	51	27	9	41
Segment 3 (RM 4.05 to RM 4.81)	85	56	31	-	56	42	19	-
Segment 4 (RM 4.81 to RM 5.0)	28	17	-	-	22	13	-	-
Total	**249**	**120**	**87**	**117**	**179**	**92**	**71**	**53**

Notes:
1. In addition, seven surface (0–10 cm), three intertidal subsurface (0–45 cm), and four subtidal subsurface (0–60 cm) field duplicates were analyzed.
2. The number of 0–60-cm samples does not include shoal cores.
3. Sample depths for subsurface samples in shoaling areas varied depending on the depth of the shoal at each location (see PDI QAPP Figure 4-1) (Windward and Anchor 2020). Details for each shoaling location are presented in Appendix A.
PDI: Pre-Design Investigation
QAPP: Quality Assurance Project Plan
RM: river mile

The samples were analyzed in three tiers (Tiers 1, 2, and 3). Tier 1 samples (263 samples[4]) were analyzed for all applicable analytes, with a subset of samples analyzed for dioxins/furans (62 samples[5]). Following a review of the unvalidated Tier 1 data and consultation with EPA, Tier 2 analyses were conducted for 141 samples. The Tier 2 analyses included selected analytes that exceeded the RALs in nearby Tier 1 samples or were analyzed for additional spatial coverage. The unvalidated Tier 2 data were also reviewed in consultation with EPA to determine the Tier 3 analyses. Using the same rationale for Tier 2 sample analysis selection, 13 samples were selected and analyzed for PCBs in Tier 3. All samples analyzed in any tier were also analyzed for TOC and total solids. Only Tier 1 samples were analyzed for grain size. A summary of the total number of samples analyzed for each COC is presented in Table 2-4. Field duplicate samples are not included in the sample counts.

[4] In addition, 14 field duplicates were analyzed for applicable analytes.
[5] In addition, six field duplicates were analyzed for dioxins/furans.

Table 2-4
Total Number of Chemical Analyses by Interval in Phase I

Sediment Type	Depth Interval	No. of Samples Analyzed						
		PCB Aroclors	Dioxins/ Furans	Other Benthic Risk Drivers[1,2]	Arsenic	PAHs	TOC/Total Solids	Grain Size
Surface Sediment	0–10 cm[3]	175	43	146	133	146	179	129[4]
Subsurface Sediment	Intertidal (0–45 cm)[5]	92	38	9	67	45	92	66
	Subtidal (0–60 cm)[6]	69	7	27	24	27	71	46
	Shoal intervals	53	4	24	23	24	53	21

Notes:
1. Other benthic risk drivers include remedial action objective 3 COCs; PAHs, PCBs, and arsenic are counted separately.
2. Tier 2 samples were analyzed for a specific subset of benthic risk drivers as determined by Tier 1 RAL exceedances or to address spatial coverage.
3. In addition, seven surface sediment field duplicate samples were collected and analyzed for PCB Aroclors, other benthic risk drivers, TOC, total solids, and grain size. Three of the seven surface sediment field duplicate samples were analyzed for dioxins/furans.
4. One grain size sample was accidentally disposed of by the laboratory prior to analysis.
5. In addition, three intertidal subsurface sediment field duplicate samples were collected and analyzed for PCB Aroclors, other benthic risk drivers, TOC, total solids, and grain size. One of the three intertidal subsurface sediment field duplicate was analyzed for dioxins/furans.
6. In addition, four subtidal subsurface sediment field duplicate samples were collected and analyzed for PCB Aroclors, other benthic risk drivers, TOC, total solids, and grain size. Two of the four subtidal subsurface sediment field duplicate samples were analyzed for dioxins/furans.

COC: contaminant of concern
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
RAL: remedial action level
TOC: total organic carbon

2.1.2.2 Laboratory Deviations from the PDI QAPP

Three deviations from the methods and procedures described in the PDI QAPP (Windward and Anchor 2020) occurred in the laboratory analysis. These deviations did not affect the data quality.

- A different PCB standard reference material (CRM911-50g) than the standard reference material listed in the PDI QAPP (Puget Sound reference material) was analyzed for sample delivery group 20F0288. The recovery was within quality control (QC) limits.
- Hexachlorobenzene was missing from the EPA 8081 initial calibration verification standard in sample delivery group 20F0109. The continuing calibration recoveries were within QC limits.

- The grain size sample jar for location LDW20-SS113 was inadvertently disposed of by the laboratory. There is no grain size result for this location.

2.1.2.3 Data Validation Results

Independent data validation was performed on all analytical chemistry results by Laboratory Data Consultants, Inc. Stage 4 validation was performed on a minimum of 10% of the data or a single sample delivery group, as specified in the PDI QAPP (Windward and Anchor 2020). Stage 2B validation review was conducted on the remaining datasets.

The data validation reports, which are presented in Appendix B, include detailed information regarding all data qualifiers. No data were rejected. The issues that resulted in the greatest number of J-qualified results were: 1) calibration verification percent differences > 20% for select PCB Aroclors and SVOC compounds, and 2) laboratory control sample (or certified reference material) percent recoveries outside of QC limits for select SVOC compounds. All data presented in this report were determined to be acceptable for use as qualified.

2.1.3 Sediment Chemistry Results

A summary of RAL exceedances in the Phase I dataset is presented in Table 2-5. The Phase I dataset indicated PCBs were the primary COC in the upper reach (i.e., had the most RAL exceedances). Other COCs with at least one RAL exceedance included dioxins/furans, mercury, polycyclic aromatic hydrocarbons (PAHs), butyl benzyl phthalate (BBP), benzoic acid, and phenol. cPAH toxic equivalents (TEQs) were also greater than the ROD RAL at three locations. No PDI locations had cPAH TEQs greater than the proposed revised RALs presented in the EPA explanation of significant differences (ESD) (EPA 2021) expected to be finalized in 2021.

Table 2-5
Summary of Sample Analyses with RAL Exceedances in Phase I PDI Dataset

Contaminant	Surface Sediment (0–10 cm)		Subsurface Sediment					
			Intertidal Sediment (0–45 cm)		Subtidal Sediment (0–60 cm)		Shoal Intervals	
	N	No. > RAL	N	No. > RAL	N	No. > RAL	N	No. > RAL
Human Health COCs[1]								
Total PCBs	175	21	92	10	69	17	53	0
Dioxin/furan TEQ	43	2	38	3	7	0	4	0
Benthic COCs								
Metals[2]								
Mercury	138	1	9	0	26	0	24	1
PAHs[3]								

Contaminant	Surface Sediment (0–10 cm)		Subsurface Sediment					
			Intertidal Sediment (0–45 cm)		Subtidal Sediment (0–60 cm)		Shoal Intervals	
	N	No. > RAL	N	No. > RAL	N	No. > RAL	N	No. > RAL
Acenaphthene	135	2	9	1	26	0	22	0
Benzo(a)anthracene	135	1	9	1	26	0	22	0
Benzo(a)pyrene	135	1	9	1	26	0	22	0
Benzo(g,h,i)perylene	135	2	9	1	26	0	22	0
Total benzofluoranthenes	135	1	9	1	26	0	22	0
Chrysene	135	1	9	1	26	0	22	0
Dibenzo(a,h)anthracene	135	1	9	1	26	0	22	0
Fluoranthene	135	1	9	1	26	0	22	1
Fluorene	135	1	9	1	26	0	22	0
Indeno(1,2,3-cd)pyrene	135	1	9	1	26	0	22	0
Phenanthrene	135	2	9	1	26	0	22	0
Total high-molecular-weight PAHs	135	1	9	1	26	0	22	0
Total low-molecular-weight PAHs	135	1	9	1	26	0	22	0
Phthalates[4]								
BBP	134	2	9	0	24	0	21	0
Other SVOCs[5]								
Benzoic acid	134	1	9	0	24	0	21	0
Phenol	133	1	9	0	24	0	21	0

Notes:
1. Arsenic concentrations did not exceed the RAL in any PDI samples, and cPAH TEQ did not exceed the proposed revised cPAH RALs in the 2021 cPAH ESD (EPA 2021).
2. Cadmium, copper, chromium, lead, silver, and zinc concentrations did not exceed RALs in any samples.
3. 2-methyl naphthalene, anthracene, naphthalene, and pyrene did not exceed RALs in any samples.
4. BEHP and dimethyl phthalate did not exceed RALs in any samples.
5. 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, dibenzofuran, hexachlorobenzene, n-nitrosodiphenylamine, and pentachlorophenol did not exceed RALs in any samples.
BBP: butyl benzyl phthalate
BEHP: bis(2-ethylhexyl) phthalate
COC: contaminant of concern
cPAH: carcinogenic polycyclic aromatic hydrocarbon
ESD: explanation of significant differences
N: sample count
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
PDI: Pre-Design Investigation
RAL: remedial action level
SVOC: semivolatile organic compound
TEQ: toxic equivalent

Of the 179 surface samples analyzed, 25 had RAL exceedances of at least 1 COC. PCBs exceeded the RAL in 21 locations (12% of samples). At 17 locations, PCBs were the only COC that exceeded the RAL. Two locations exceeded the RALs for PCBs and BBP (SS227 and SS266). One location exceeded the RALs for PCBs and mercury (SS304). One location exceeded the RALs for PCBs and benzoic acid (SS411). Two locations exceeded only the RAL for PAHs (SS379 and SS383), one location had only a dioxin/furan TEQ (SS301) greater than the RAL, and one location exceeded only the RAL for phenol (SS308).

RAL exceedances were associated with 12 of 92 intertidal subsurface samples (0–45 cm). PCB concentrations were greater than the RAL at 10 locations (11% of samples). One location had only a RAL exceedance for dioxin/furan TEQ (IT302), and one location had RAL exceedances for PAHs (IT379). RAL exceedances were associated with 17 of 69 locations with subtidal subsurface (0–60-cm) samples. PCBs were the only COC that exceeded the RAL in this interval, which had RAL exceedances in 25% of the 0–60-cm sediment samples. In the shoaling area cores, only one location had RAL exceedances; concentrations of one polycyclic aromatic hydrocarbon (PAH) (fluoranthene) and mercury exceeded their respective RALs at location 148. There were no PCB exceedances in the shoaling cores.

Per EPA request, contaminant concentrations in surface sediment (0–10-cm) and subsurface sediment (0–45- or 0–60-cm) intervals were compared for all locations with both surface and subsurface data. As shown in Appendix D, there was a correlation between contaminant concentrations in the 0–10-cm and 0–45-cm intervals collected from the same intertidal location for PCBs, cPAHs, dioxins/furans, and arsenic. The results are distributed above and below the 1:1 line, indicating no bias for concentrations in the surface interval (0–10 cm) to be consistently greater or less than those in the subsurface 0–45-cm interval. PCB concentrations and cPAH TEQs in the surface (0–10 cm) and subsurface (0–60 cm) sediment in the subtidal were also correlated (Appendix D). PCB concentrations and cPAH TEQs tended to be greater in the subsurface (0–60 cm) than the surface (0–10 cm) sediment.

Maps 2-3a through 2-3e present the locations of Phase I PDI samples and pre-PDI data, as well as the locations with RAL exceedances within each of the four segments of the upper reach. The number of RAL exceedances at Phase I PDI locations are presented in Table 2-6 and summarized below.

Table 2-6
Number of RAL Exceedances by Segment in the Phase I PDI samples

Interval	Human Health COCs and No. of RAL Exceedances				Benthic COCs and No. of RAL Exceedances									
	Total PCBs		Dioxin/ Furan TEQ		Mercury		PAHs		Benzoic Acid		Phenol		BBP	
	N	No. > RAL	N	No. > RAL	N	No. > RAL	N	No. > RAL	N	No. > RAL	N	No. > RAL	N	No. > RAL
Segment 1														
0–10 cm	49	6	5	0	32	0	32	0	32	0	32	0	32	0
0–45 cm	10	0	2	0	-	-	-	-	-	-	-	-	-	-
0–60 cm	42	15	3	0	12	0	12	0	11	0	11	0	11	0
Shoal cores	12	0	-	-	5	1	5	1	4	0	4	0	4	0
Segment 2														
0–10 cm	51	7	16	0	42	0	40	0	40	0	40	0	42	2
0–45 cm	27	3	14	1	4	0	4	0	4	0	4	0	4	0
0–60 cm	9	1	1	0	7	0	6	0	6	0	6	0	6	0
Shoal cores	41	0	4	0	19	0	17	0	17	0	17	0	17	0
Segment 3														
0–10 cm	53	4	20	2	49	1	48	2	45	0	46	1	45	0
0–45 cm	42	7	20	2	5	0	5	1	5	0	5	0	5	0
0–60 cm	18	1	3	0	7	0	8	0	7	0	7	0	7	0
Segment 4														
0–10 cm	22	4	2	0	15	0	15	0	17	1	15	0	15	0
0–45 cm	13	0	2	0	-	-	-	-	-	-	-	-	-	-

Notes:
BBP: butyl benzyl phthalate
COC: contaminant of concern
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
PDI: Pre-Design Investigation
RAL: remedial action level
TEQ: toxic equivalent
N: sample count

In Segment 1, only PCB concentrations exceeded the RAL in PDI surface (0–10-cm) and subtidal subsurface (0–60-cm) samples (Map 2-3a). There were no RAL exceedances in the 0–45-cm interval in the intertidal areas, although there were PCB RAL exceedances in the 0–10-cm interval in intertidal sediment near the South Park Bridge (Map 2-3a). None of the shoaling cores had PCB RAL exceedances, though one shoal core (SC148) had PAH (fluoranthene) and mercury concentrations

exceeding the RALs. Most of the PCB RAL exceedances were in subsurface sediment (0–60-cm) in the FNC along the Boeing Plant 2 early action area (EAA).

In Segment 2 (Map 2-3b), PCB concentrations exceeded the RAL at two PDI locations along the Jorgensen Forge EAA boundary (one 0–10-cm sample and one 0–60-cm sample), and there were RAL exceedances (PCBs in four 0–10-cm samples, PCBs and dioxins/furans in one 0–45-cm sample, and PCBs and BBP in two 0–10-cm samples) in the intertidal PDI samples between RM 3.8 and RM 4.0 on the eastern shoreline. On the western shoreline, PCB concentrations in two 0–45-cm intertidal samples (IT224 and IT253) exceeded the RAL. None of the PDI shoal cores had RAL exceedances in Segment 2.

In Segment 3, most of the PDI RAL exceedances were in the intertidal sediment samples adjacent to Container Properties. Surface (0–10 cm) and subsurface (0–45 cm) sediment concentrations in this area exceeded RALs primarily for PCBs, but also for dioxins/furans, mercury, and phenol in one sample each (Map 2-3c). In Slip 6, the PCB concentration in one subsurface (0–60 cm) sediment sample exceeded the RAL (SC349). In addition, PAH concentrations exceeded RALs at two locations, with 0–10-cm and 0–45-cm RAL exceedances at one location on the east side of the Turning Basin area and 0–10-cm RAL exceedances at one location on the west side (Map 2-3d).

In Segment 4, locations along the eastern shoreline in the areas north and adjacent to the Norfolk EAA had RAL exceedances (Map 2-3e). Four 0–10-cm PDI samples collected along the eastern shoreline had PCB concentrations that exceeded the RAL and one location also had a benzoic acid exceedance in the 0–10-cm interval.

2.1.4 Field Observations and Sediment Grain Size Results

Field observations of the sediment cores are provided in Appendix A (Table A-3). Visually distinct layers of silt and sand were observed in 27 of 120 (23%) intertidal subsurface samples (0–45 cm) and in 15 of 87 (17%) subtidal subsurface samples (0–60 cm). In general, the cores were homogenous. In the FNC, deeper cores with more sample intervals were collected to characterize the shoaled material above -15 ft MLLW, as well as the 2-ft interval below this depth. The depositional material in the shoal cores was also generally homogeneous, although visually distinct layers of silt and sand were observed in 7 of the 40 (18%) shoal cores.

Grain size testing was completed on 262 of the 263[6] Tier 1 surface and subsurface sediment samples. In addition, grain size testing was completed on 14 field duplicates. Sample locations are shown in Appendix C on Map C-1. Grain size testing was not conducted on samples analyzed in Tiers 2 and 3.

[6] Grain size was inadvertently not analyzed in SS113 (0–10 cm). See Section 2.1.2.2 for details.

In general, grain size data indicated that surface (0–10-cm) and subsurface (0–45-cm and 0–60-cm) samples are predominantly sand and silt, with varying gravel and clay compositions. Specific percentage ranges of gravel, sand, silt, and clay detected in samples analyzed for grain size were as follows:

- Gravel: 0–38%
- Sand: 4–99%
- Silt: 4–80%
- Clay: 1–26%

Appendix C presents the grain size results.

2.2 Bank Visual Inspection

2.2.1 Methods

The Phase I visual inspection of banks was conducted to address DQO 8 (Table 1-2), building upon the existing Waterway User Survey (Integral et al. 2018) by collecting additional detail to support engineering design. Section 2.1.7 of the RDWP (Anchor and Windward 2019a) stated: "LDW upper reach banks are defined as the transition area from the LDW subtidal or intertidal bed to the upland areas above MHHW. The banks are typically delineated as starting at the toe, where the relatively flat waterway bed (which will vary in elevation) begins to steeply slope to the top of bank (i.e., area where the slope flattens in the upland and is located above MHHW)."

Based on visual observations, banks were broadly classified as armored, unarmored, or bulkheaded, consistent with the Waterway User Survey (Integral et al. 2018). Maps 2-4a through 2-4f show an updated classification of bank type based on Phase I visual observations. Consistent with Section 2.1.7 of the RDWP (Anchor and Windward 2019a), "armored banks" refer to banks that have engineered surface armoring, while banks that have no armoring, discontinuous armoring, or poorly placed/maintained armoring are considered "unarmored." Vegetated banks are also classified as "unarmored." Because what constitutes the toe of a bank can be subjective, for this DER, the toe of an armored bank is defined as the start of the armor material; for bulkheads, the toe is defined as the base of the vertical bulkhead. The toe of an unarmored bank was previously defined as "where the relatively flat waterway bed (which will vary in elevation) begins to steeply slope to the top of bank." The Waterway User Survey also defined "dock faces" as a fourth type of bank. The dock faces classification is not being carried forward to characterize banks for RD. "Dock faces" refer to docks, which are covered in Section 2.3.

In addition to the broad classification of bank type, detailed observations were collected to note the presence of the following features (as applicable[7]), per the PDI QAPP (Windward and Anchor 2020):

- Type of armor material
- Estimated slope/grade
- Presence of sediment accumulated on armored slopes
- Observed bank erosion
- Observed utility crossings
- Observed outfalls/pipes
- Observed discharge flowing from outfalls
- Navigational obstructions
- Access points
- Vegetation

The only field deviation from the PDI QAPP (Windward and Anchor 2020) that occurred during the bank visual inspection was related to the method of documenting visual observations. Appendix D-3 of the PDI QAPP included a shoreline visual inspection form that proved to be too rigid to adequately document detailed observations of shoreline features, which vary significantly along the site. The alternative method of field data collection included use of a tablet and the ArcGIS Collector, supplemented by field notes handwritten directly on figures to better tie observations to locations. The field data entered into ArcGIS Collector were continually uploaded to a project database. This field deviation did not affect the data quality and allowed the field team to more accurately and efficiently collect field data.

A shoreline stationing system was developed as a reference for the bank and structures visual inspections to provide reference points for visual observations. The stationing system for the upper reach follows the Waterway User Survey (Integral et al. 2018) shoreline structure boundary, which was applied to the entire LDW site. As such, the stationing begins on the LDW eastern bank at RM 0.0 (south of Harbor Island) and follows the top of bank line running upstream along the east bank to RM 5.0, and then continues downstream along the western shoreline top of bank line back to RM 0.0 (i.e., clockwise; see Maps 2-4a through 2-4f for reference) at 100-ft intervals. The first interval shown on Map 2-4a is 248.

[7] While the visual bank inspection was conducted at low tide to maximize observations, this timing also limited the ability of the inspection vessel to get close to the shoreline and some features were difficult to document, including potential discharges from outfalls at the time of the survey. These features will be further investigated for areas with RAL exceedances during Phase II PDI.

2.2.2 Results

The Phase I bank inspection was conducted primarily by boat around daytime low tides (two hours before and two hours after) on June 11, 16, 18, 23, and 26, and August 4, 2020. Approximately 41% of the upper reach bank areas are armored, 46% are unarmored, and 13% are bulkheaded. Vessel access to some of the areas for Phase II PDI bank sampling will be limited due to shallow water conditions; access from the uplands is generally possible, although some bank areas are heavily vegetated and equipment access may be difficult in some areas. No unique safety concerns were noted for specific bank areas that would prohibit bank characterization.

After completion of the Phase I bank visual inspection, habitat restoration work was conducted by the Port of Seattle at the Duwamish River People's Park and Shoreline Habitat site (located adjacent to The Boeing Company's South Park property) along the western shoreline from approximately RM 3.68 to RM 3.9, above a toe elevation ranging from +4 to +8 ft MLLW. Therefore, the Phase I bank visual observations for that stretch of the west bank are no longer representative of bank conditions.

Detailed observations are documented for each discrete shoreline segment in Attachments E-1a and E-1b in Appendix E. Shoreline segments are shown on Maps 2-4a through 2-4f. Photographs and videos from the bank visual inspection will be provided to EPA as an attachment to Appendix E in DVD format.

2.3 Structures Visual Inspection

The Phase I structures visual inspection was conducted to support DQO 8 (as described in Section 5.2 of the PDI QAPP) and confirmed and supplemented the identified structures and observations in the existing Waterway User Survey (Integral et al. 2018). The inspection also provided additional information, including any discrepancies and changed conditions, to support engineering design. The inspected structures consisted of overwater structures (wharfs, piers, docks, etc.), in-water structures (piles, pile groups, dolphins, berths, etc.), and shoreline structures and utilities (outfalls, bulkheads, wing walls, etc.).

For this inspection, each unique structure was classified as a Structure (noted on Maps 2-4a through 2-4f and Appendix F as "ST-##") (i.e., shoreline, overwater, and in-water structures) or an Outfall (noted on Maps 2-4a through 2-4f and Appendix F as "OF-##") (i.e., shoreline utility). These structures were numbered sequentially heading up-station (i.e., clockwise, starting at RM 3.0E), based on the shoreline stationing system described in Section 2.2. For purposes of uniformity and correlation with previous studies, references to existing labels are used where applicable. For structures, reference to the Waterway User Survey numbering (WUS#) is shown in addition to the Phase I PDI label, although several structures identified during the Phase I PDI were not included in

the Waterway User Survey and do not have a corresponding WUS# label. As such, the Phase I PDI classification is shown as the primary structure designation on Maps 2-4a through 2-4f.

Outfalls have been documented comprehensively in previous studies, including the *Lower Duwamish Waterway Outfall Inventory Update: January 2012 – February 2014* (Leidos 2014) and Appendix H of the LDW RI report (Windward 2010), and all outfalls observed during the Phase I PDI have been previously documented. Therefore, the labels from those existing studies have been adopted as the primary designations for outfalls identified during this investigation, with Phase I PDI classification included as a secondary designation on Maps 2-4a through 2-4f.

Structural visual inspection was conducted by boat during low tides the morning of June 15, 2020, and the afternoon of July 17, 2020. The inspection was limited to boat-accessible areas. Information collected during the structural visual inspection included:

- General observations of structure condition, visible physical damage, and surface deterioration or defects of structure component materials
- Information to supplement existing data in the Waterway User Survey (Integral et al. 2018), including structure identification numbers, physical descriptions of the structures observed, and notations of any discrepancies or changed conditions
- Visual assessments of access or safety concerns that may be important considerations for chemistry or geotechnical sampling in the vicinity of or beneath the structure during Phase II

Details of the general observations, information to supplement existing data in the Waterway User Survey (Integral et al. 2018), and accessibility/safety concerns are included in Appendix F for 21 structures and 26 outfalls.[8]

2.4 2020 Bathymetric Survey to Fill Bathymetric Data Gaps

A 2020 bathymetric survey was performed to fill data gaps remaining from the Phase I 2019 bathymetric survey to complete bathymetric survey coverage of the upper reach. No bathymetry coverage data gaps remain for the upper reach. The 2019 bathymetric survey results were presented

[8]The Phase I PDI visual bank and structures inspections documented observations for outfalls that were visible from the inspection vessel and did not locate every known outfall previously identified in the upper reach. Information for outfalls not included in Appendix F is available in the *Lower Duwamish Waterway Outfall Inventory Update: January 2012 – February 2014* (Leidos 2014), and will be reviewed and supplemented, as necessary, during Phase II PDI sampling.

in the PDI QAPP (Windward and Anchor 2020). The 2020 bathymetric survey combined with the 2019 survey achieved the DQOs established in the survey QAPP (Anchor and Windward 2019b) as follows:

- DQO 1 – "Provide the bathymetric data to generate new sun illumination maps … to potentially modify the recovery category area designations." The 2019 bathymetric survey sufficiently addressed this DQO; however, the 2020 bathymetric survey filled in a few data gaps in coverage that are assessed in this DER for potentially modifying recovery category designations.
- DQO 2 – "Define the current bathymetry of the LDW Upper Reach with sufficient confidence … to inform selection of sampling locations for Pre-Design Investigation data collection to support the RD." The 2019 bathymetric survey sufficiently addressed this DQO, and the full survey coverage (2019 and 2020) will be used for Phase II QAPP Addendum preparation.
- DQO 3 – "Provide a base map, subject to modification with the addition of follow-up bathymetric and topographic survey data, if needed, for the RD." The 2019 bathymetric survey did not completely address this DQO. The 2020 bathymetric survey filled in data gaps in the 2019 bathymetric survey and completed DQO3 for aquatic areas of the site.

The 2020 bathymetric survey was performed on June 15 and 16, 2020, by Northwest Hydro, Inc., which also performed the 2019 bathymetric survey. The equipment and methods used to perform the 2020 survey were the same as those used for the 2019 bathymetric survey, per the approved survey QAPP (Anchor and Windward 2019b). The precision and accuracy of the two surveys were the same and yielded compatible data. There were no deviations from the survey QAPP. The key targets and related data for the 2019 and 2020 surveys are summarized in Table 2-8.

Table 2-8
Key Targets and Related Datums

Description	Quantity or Datum
Horizontal Positioning Accuracy	1.6 ft minimum
Horizontal Survey Accuracy	3 ft at a 95% confidence interval
Horizontal Datum	North American Datum of 1983/1991 Washington North Zone
Vertical Survey Accuracy	+/- 0.5 ft at a 95% confidence interval
Vertical Datum	MLLW

Notes:
Source: Table 3 of the survey QAPP (Anchor and Windward 2019b).
MLLW: mean lower low water
QAPP: quality assurance project plan

An updated three-dimensional bathymetric surface for the upper reach was created by combining the 2019 and 2020 Northwest Hydro, Inc. bathymetric surveys and part of the January 2020 US Army Corps of Engineers (USACE) FNC survey. USACE conducted maintenance dredging within the FNC from approximately RM 4.05 to RM 4.71 from December 2019 to January 2020. The January 2020 survey results reflect the post-dredge condition within the dredged channel. The combined bathymetric survey limits of each of the three surveys are presented in Map 2-5. Northwest Hydro Inc.'s report for the supplemental 2020 bathymetric survey is provided in Appendix G.

The three-dimensional bathymetric surface and elevation contours are presented in Maps 2-6a through 2-6d. One survey anomaly was noted in the 2020 Northwest Hydro Inc. survey at the head of Slip 6, where the surveyor indicated an underwater tree and root ball floating above the sediment bed. The bathymetric survey data from 2019 did not show this underwater feature; therefore, the 2019 survey data were kept in this Slip 6 area instead of being replaced by the 2020 data, as the underwater tree and root ball may be transient.

3 Data Evaluations

This section presents a summary of the data rules used to define the Phase I design dataset, a review of the recovery categories based on Phase I sediment chemistry data and 2020 bathymetric data, and preliminary RAL exceedance area delineation and remedial technology assignment options. These evaluations enable the identification of Phase II data gaps, discussed in Section 4.

3.1 Data Management Rules for the Design Dataset

The LDW database includes all sediment data that have been collected in the LDW. The subset of the sediment data used in geostatistical models to delineate areas with RAL exceedances in the upper reach (see Section 3.3) are referred to as the design dataset. This dataset will be expanded throughout the design process as additional data become available (e.g., Phase II data).

The design dataset has been constructed following the data management rules provided in Appendix H. This dataset includes RI/FS data,[9] post-FS data, and the Phase I PDI data presented in this DER. The steps followed in creating the design dataset are as follows:

1. Identify all samples that have been analyzed for chemicals with RALs.
2. Exclude any samples that are:
    - Located within EAAs
    - Located within an area that has been dredged
    - Collected as part of a monitoring program and superseded by newer data (e.g., data from monitoring year 1 are superseded by those from monitoring year 2)
    - Collected from depth intervals that are not representative of RAL intervals (e.g., 0–2 cm, 0–4 ft)[10]
3. For subtidal locations with multiple sample depths within the 0–60-cm RAL interval, average the results to create a single concentration per contaminant that represents the 0–60-cm interval (i.e., results from a 0–30-cm sample and a 30–60-cm sample are averaged to represent the 0–60-cm interval).
4. Exclude composite samples, as they do not provide location-specific information.
5. Where surface sediment locations have been re-occupied since the FS and the 2018 pre-design baseline sampling (under the third amendment to the Administrative Order on Consent), select more recent data (if collected within 10 ft[11]) to represent current conditions.

[9] The data management rules that were used to construct the RI/FS database are described in Appendix E of the LDW RI (Windward 2003).

[10] Core intervals deeper than 60 cm are retained in the design dataset to delineate vertical extent.

[11] The 10-ft rule is consistent with inherent measurement error in the differential global positioning systems (GPSs) used in sampling surveys for the Phase I PDI and past sampling efforts. The differential GPS used for Phase I surface

If an older sample includes data for contaminants not analyzed in the newer sample, retain the older chemistry in the dataset. This rule has remained consistent since the establishment of the RI dataset (LDW RI Appendix E (Windward 2003)). The purpose of this rule is to include the most current result available for the 0–10-cm interval for comparison to RALs since surface sediments can change over time as new sediment is deposited.

The only data rules that are new for the design dataset involve field duplicates and PCBs. With respect to field duplicates, parent sample results were selected when both parent and field duplicate results were reported, except when a RAL exceedance occurred only in the field duplicate and not in the parent. In such a case, the field duplicate results were selected for all analytes. For PCBs, both PCB Aroclor and congener sums were compared to the PCB RAL. In cases where a sample was analyzed for both, the greater of the two sums was selected for the design dataset.

Table 3-1 shows how many sampling locations were contributed by the Phase I PDI and earlier datasets to the design dataset for each of the RAL sediment depth intervals.

Table 3-1
Number of Design Dataset Locations in the Upper Reach by Data Source

Dataset	Date Range	No. of Surface (0–10 cm) Locations	Subsurface Sediment Locations		
			No. of Intertidal (0–45 cm)	No. of Subtidal (0–60 cm)	No. of Shoal
RI/FS	1990–2010	358	0	9	0
Post-FS	2010–2019	220	0	0	7[1]
PDI (Phase I)	2020	178	92	70	30[2]
Total		**756**	**92**	**79**	**37**

Notes:
1. Post-FS shoal locations have a total of 16 discreet depth interval samples.
2. PDI Phase I shoal locations have a total of 53 discreet depth interval samples.
PDI: Pre-Design Investigation
RI/FS: remedial investigation/feasibility study

3.2 Recovery Category Assessment

Recovery categories are used to help identify the spatial application of RALs and remedial technologies (EPA 2014). Recovery category areas were developed in the FS (AECOM 2012) and subsequently re-assessed and revised in the *Recovery Category Recommendations Report* (Integral et al. 2019) and in Appendix B of the PDI QAPP (Anchor and Windward 2019b). Per Section 3.4 of the

sediment sampling has a measurement error of approximately 3–6 ft. Given the inherent measurement error, it is not possible to definitively distinguish different sampling locations within 10 ft of one another for samples collected after 2001. Prior to 2001, GPS technology was less accurate, so measurement errors may have been greater. If a re-occupied station location was greater than 10 ft away from the old location, it was considered a separate sample location and the older data were retained.

RDWP (Anchor and Windward 2019a), the recovery category areas in the upper reach were again re-assessed in this DER by comparing the chemistry data collected during the Phase I PDI to data collected previously at locations that were reoccupied (i.e., resampled within 10 ft). The assessment is presented in detail in Appendix I.

Sediment chemistry at the reoccupied locations was evaluated using the methodology outlined in the *Recovery Category Recommendations Report* (Integral et al. 2019). Four COCs (PCBs, cPAHs, arsenic, and bis(2-ethylhexyl)phthalate [BEHP]) were evaluated at 50 locations in the upper reach. Individual locations were identified as increasing in concentration, decreasing in concentration, not changing, or as having concentrations below the Washington State Sediment Management Standard (SMS) benthic sediment cleanup objective (SCO) or lowest RAL for cPAHs. The data were then evaluated in the context of previous recovery category evaluations, including other lines of evidence used for recovery category determinations.

As shown in Appendix I, this analysis showed generally declining contaminant concentrations over time, consistent with the conceptual site model. cPAHs and BEHP showed recovery (e.g., average PDI concentrations were less than one-third of earlier concentrations). All arsenic concentrations were below the benthic SCO and did not trend up or down. Total PCB concentrations were declining or already below the benthic SCO in most locations, though four intertidal locations had increasing concentrations. These results are consistent with the comparison of 0–10-cm and 0–60-cm results presented in Appendix D.

Based on this analysis, one area from RM 4.0 to RM 4.05 is recommended to be modified from Recovery Category 3 to Recovery Category 2 based on mixed chemistry results in this area (Map 3-1; Appendix I). No other modifications based on chemistry are recommended. The final recovery category area designations are shown on Map 3-2.

In addition to the contaminant trend analysis for reoccupied locations, per Section 3.4 of the RDWP (Anchor and Windward 2019a), the recovery category assignments were re-assessed in three small portions of the upper reach that were surveyed in 2020 to fill in missing survey coverage from the 2019 bathymetric survey. All three of these areas have frequent vessel traffic and were previously designated as Recovery Category 1. The additional bathymetric survey data and sun illumination mapping do not suggest revising the recovery category designation in these areas.

3.3 Areas with RAL Exceedances and Preliminary Technology Assignments

This section presents the areas with RAL exceedances and preliminary technology assignment options for each area in order to identify data gaps for Phase II sampling.

3.3.1 Defining Areas with RAL Exceedances

One of the primary objectives of this Phase I DER is to delineate areas with RAL exceedances using the design dataset. Delineation at this point in the design process provides an indication of where remediation will occur and also serves to identify Phase II data gaps so RAL exceedance areas can be further refined. Phase II sampling will include the collection of additional sediment and bank data to refine the horizontal extent of these areas based on RAL exceedances,[12] and to evaluate their vertical extents where appropriate based on preliminary remedial technology options.

For this preliminary assessment, two data interpolation methods were used to identify areas with RAL exceedances. Inverse distance-weighted interpolations were used to delineate areas with PCB RAL exceedances, and Thiessen polygons were used to delineate areas with RAL exceedances of other COCs. The overlay of these two interpolations delineates the areas with RAL exceedances. The majority of the area (91%) was defined by the interpolated PCB data because most of the RAL exceedances were for PCBs. The remaining area was based on other COCs using Thiessen polygons. As such, the Thiessen polygons increased by 9% the areal extent of the RAL exceedance area defined by PCBs. Two areas in the Turning Basin were delineated based on PAHs alone. In total, 37 areas with RAL exceedances were identified in this Phase I DER (Map 3-3). These 37 areas will be further refined throughout the design process and ultimately developed into sediment management areas (see Table 1-1). The process to delineate these RAL exceedance areas is described in more detail in Appendix J. The interpolation method and its parameterization will be revisited with EPA prior to the Phase II DER to identify the interpolation approach that will be used for the Phase II DER.

Details of each RAL exceedance area are summarized in Section 4.6, where data gaps for Phase II sampling are identified. Additionally, cross section views of select RAL exceedance areas that show surrounding features (e.g., sample locations, the FNC, bank conditions, etc.) are included as Maps 3-4a through 3-4f to help illustrate the spatial interpolations relative to data points and bathymetry, and to help identify Phase II data gaps.

3.3.2 Preliminary Remedial Technology Assignments

Figures 19 and 20 in the ROD[13] describe the process by which remedial technologies are to be assigned during the design process. A variety of factors govern the preliminary selection of applicable remedial technologies, including mudline elevation, RAL exceedance factor, depth of contamination, and recovery category designation.

[12] RALs are listed in ROD Table 28 for 0–10-cm, 0–45-cm (intertidal), 0–60-cm (subtidal), and shoaling intervals.
[13] Figure 20 was corrected after the ROD was published. Reference to Figure 20 herein refers to the corrected version, which was published in a memorandum from EPA dated August 26, 2015.

There are different remedial technologies that may be applicable in each area with RAL exceedances, and these may conflict with each other from a constructability standpoint. Therefore, the final remedial technology assignment within each area will be determined during 30% and 60% RD by factoring in engineering and constructability considerations, in order to develop a constructable, stable, and protective design.

Potential remedial technologies identified in the ROD for intertidal and subtidal areas include the following:

- Intertidal:
  - Monitored natural recovery (MNR)
  - Area-specific technology[14]
  - Enhanced natural recovery (ENR)
  - Partial dredge and cap
  - Dredge and backfill
- Subtidal:
  - MNR
  - Area-specific technology
  - ENR
  - Dredge (with backfill in habitat areas)[15]
  - Cap or armored cap

Three examples are provided below to illustrate how preliminary technology assignments were determined for the Phase I DER, following the decision process in ROD Figures 19 and 20.

The first example illustrates preliminary assignment of dredge or partial dredge and cap, the second example illustrates the preliminary assignment of ENR, and the third example illustrates a RAL exceedance area that has multiple subareas, each resulting in different preliminary remedial technology assignments. Preliminary technology assignments for each RAL exceedance area are described in Appendix K and summarized in Section 4.6.

Example 1: Dredge or Partial Dredge and Cap Scenario (Area 8). RAL Exceedance Area 8 is located within the FNC; therefore, ROD Figure 20 was used to determine applicable preliminary technology assignment(s), as follows:

[14] In areas with structural or access restrictions, area-specific cleanup technologies will be applied as described in ROD Section 13.2.1.3.

[15] Habitat areas were defined in the FS as all areas above -10 ft MLLW.

- Are any sediment COC concentrations > RALs in appropriate depth intervals?
  Yes, so MNR is not applicable.
- Are there structural or access limitations?
  Potentially yes (South Park Bridge [ST-02] and cable crossing [see Appendix F]), so there may be a need to apply area-specific technology, which will be determined during 30% design.
- Is the area within a Recovery Category 1 area?
  Yes.
- Is there room for a cap?
  No, the area is within the FNC or 10-ft buffer area.
- Would > 1 ft of sediment with COCs > human health RALs or benthic SCOs remain following partial dredging to accommodate a cap?
  To be determined during Phase II PDI.

Therefore, dredge (with backfill in habitat areas) or partial dredge and cap may be applicable for RAL Exceedance Area 8. Since there is a structure within or adjacent to this area, an area-specific technology[16] may also be applicable.

Example 2: ENR Scenario (Area 35). RAL Exceedance Area 35 is located in an intertidal area. Therefore, ROD Figure 19 was used to determine applicable preliminary technology assignment(s), as follows:

- Are any sediment COC concentrations > RALs in appropriate depth intervals?
  Yes, so MNR is not applicable.
- Are there structural or access limitations?
  No.
- Is the area within a Recovery Category 1 area?
  No, this area is located in a Recovery Category 3 area.
- Are sediment COC concentrations > ENR upper limits?
  No.

Therefore, ENR is applicable for RAL Exceedance Area 35.

Example 3: Mixed Remedial Technologies Scenario (Area 7). RAL Exceedance Area 7 falls in both intertidal and subtidal areas. Therefore, both ROD Figures 19 and 20 were used to determine preliminary technology assignment options, as follows:

[16] In areas with structural or access restrictions, area-specific cleanup technologies will be applied as described in ROD Section 13.2.1.3.

Intertidal subarea:

- Are any sediment COC concentrations > RALs in appropriate depth intervals?
  Yes, so MNR is not applicable
- Are there structural or access limitations?
  Potentially yes (South Park Bridge [ST-02] and cable crossing [see Appendix F]), so there may be a need to apply area-specific technology, which will be determined during 30% design.
- Is the area within a Recovery Category 1 area?
  No
- Are sediment COC concentrations > ENR upper limits?
  There are multiple samples within the intertidal subarea. One sample exceeds the ENR upper limit, two samples do not exceed the ENR upper limit.
- Would >1 ft of sediment with COCs > human health RALs or benthic SCOs remain following partial dredging to accommodate a cap?
  To be determined during Phase II PDI.

Therefore, ENR may be applicable for a portion of the intertidal subarea. Dredge and backfill or partial dredge and cap may be applicable for other portions of the intertidal subarea. Since there is a structure within or adjacent to this area, an area-specific technology may also be applicable.

Subtidal Subarea:

- Any sediment COC concentration >RALs in appropriate depth interval?
  Yes, so MNR is not applicable.
- Are there structural or access limitations?
  Potentially yes (South Park Bridge [ST-02] and cable crossing [see Appendix F]), so there may be a need to apply area-specific technology, which will be determined during 30% design.
- Is the area within a Recovery Category 1 area?
  No.
- Sediment COC concentrations >ENR upper limits?
  No samples located within the subtidal subarea; area designation is based on interpolated data where mixed results are present in the adjacent intertidal subarea. Adjacent COC concentrations are above and below the ENR upper limit (to be confirmed during Phase II PDI).
- Room for cap or ENR?
  Yes.

Therefore, cap, armored cap, or ENR may be applicable for the subtidal subarea within RAL Exceedance Area 7. Since there is a structure within or adjacent to this area, an area-specific technology may also be applicable.

Understanding the range of applicable remedial technologies for each RAL exceedance area is necessary to identify Phase II data gaps, which can vary depending on the technologies. Section 4.6 discusses the data gaps that have been identified for all applicable remedial technologies at each RAL exceedance area. Additional data collected during the Phase II PDI and engineering considerations evaluated during 30% and 60% RD will be used to select final remedial technologies.

4 Phase II Data Gaps

This section identifies data gaps to be filled in Phase II PDI sampling to address the Phase II DQOs identified in the PDI QAPP (Table 4-1) (Windward and Anchor 2020). The general approach for data gaps identification is discussed for each DQO separately, followed by identification of the type of data gap information to be collected for each RAL exceedance area. Detailed information regarding sediment sampling locations, depth intervals, and analytes, as well as other information to be collected in Phase II, will be provided in the QAPP Addendum. The QAPP Addendum will also include an inadvertent discovery plan to describe actions that will be performed during the Phase II investigations related to cultural resources.

Table 4-1
DQOs for Phase II of the PDI in the Upper Reach

Phase II
DQO9 – If feasible, delineate RAL exceedances in areas under over-water structures.
DQO10 – Further delineate RAL exceedances, as needed for unbounded areas.[1]
DQO11 – Assess chemical and physical characteristics of banks (including topographic survey), as needed, depending on remedial technology selected for adjacent sediment and whether bank is erosional.
DQO12 – Delineate vertical elevation of RAL exceedances in dredge (and dredge/cap) areas and collect subsurface sediment chemistry data in cap areas where contamination under caps will remain.
DQO13 – Collect geotechnical data as needed depending on technology proposed and/or physical characteristics of remedial action areas.
DQO14 – Collect other engineering applicable data as needed (e.g., structures inspection, utility location verification, thickness of sediment on top of riprap layers, groundwater velocities).

Notes:
1. Toxicity testing may be used to override chemical data in RAL delineation in Phase II (DQO 10), per the ROD.
DQO: data quality objective
PDI: Pre-Design Investigation
RAL: remedial action level
ROD: Record of Decision

4.1 Refining Areas with RAL Exceedances (DQOs 9 and 10)

Additional data are needed to refine the horizontal extent of many of the areas with RAL exceedances that have been delineated based on the design dataset. General considerations for additional data, whether for surface (0–10 cm) or subsurface (0–45 or 0–60 cm) sampling, are summarized in this section. Details for each area are presented in Section 4.6.

4.1.1 General Considerations

Additional data are needed to address the following four considerations; additional considerations may be identified in the QAPP addendum.

- Collect sediment data within a "buffer" area at the northern boundary of the upper reach (RM 3.0); there is an unbounded preliminary RAL exceedance area located at the boundary.
- Collect additional data around the interpolated boundaries of areas with RAL exceedances, where needed to supplement the design dataset.
- Collect samples in RAL exceedance areas that are based on interpolated concentrations only (i.e., where subsurface RALs change based on bathymetric and recovery category boundaries). See Exceedance Area 22 on Map 3-3 as an example.
- Re-occupy locations with concentrations that exceeded only benthic RALs for toxicity testing that, if they were to pass benthic toxicity tests, would affect area boundaries.

4.1.2 ENR/AC Pilot Study Intertidal Plot

The ENR/activated carbon (AC) pilot study intertidal plot is located in the upper reach. There are two subplots, one with and one without AC added to the ENR cover material. As described below, the subplots were assessed to evaluate if they meet the intertidal RALs for Recovery Category 2.

With respect to the 0–10-cm RALs, analysis of the ENR cover material throughout the subplots results in PCB concentrations below the RALs in the surface sediment (Amec Foster Wheeler et al. 2018; Wood et al. 2019a; Wood et al. 2019b).[17] The 0–10-cm RALs for all other COCs would be met based on the chemistry data of the ENR cover material (Amec Foster Wheeler et al. 2018). This section provides an analysis of existing data as compared to intertidal subsurface RALs (0–45 cm) and recommends a confirmatory sample.

With respect to the 0–45-cm RALs, pre-construction 0–10-cm sediment data were used to calculate maximum "0–45-cm" concentrations for the COCs that have 0–45-cm RALs in Recovery Category 2 areas (PCBs, arsenic, dioxins/furans, and cPAHs). In this calculation, the 0–10-cm data were depth weighted with the ENR cover material for arsenic, dioxins/furans and cPAHs. The average thicknesses of the cover material in the subplots were 25 cm (ENR plus AC plot) and 28 cm (ENR-only plot), so 25 cm was assumed. In calculating the 0–45-cm weighted concentration, the pre-construction 0–10-cm sediment data were assumed to represent the lower 20 cm and the cover material was assumed to represent the top 25 cm.

[17] PCB concentrations have been monitored as part of the ENR/AC pilot study. Concentrations of other COCs in the construction materials were well below RAL concentrations (Amec Foster Wheeler et al. 2018).

As shown in Table 4-2, based on the above assumptions and using maximum concentration data in this area, arsenic, dioxins/furans, and cPAHs in the ENR/AC pilot study intertidal plot are expected to be well below the 0–45-cm RALs.

Table 4-2.
Estimated Maximum Concentrations of Arsenic, Dioxins/Furans, and cPAHs in the 0–45-cm Interval in ENR/AC Pilot Study Intertidal Plot Following Construction

COC	Units	Maximum Pre-construction Conc. (0–10 cm)	Cover Material Conc. (25 cm)	Calculated Max. 0–45 conc.[1]	0–45 cm RAL
Arsenic	mg/kg	23.1	2.04	11.3	28
Dioxins/Furans	TEQ ng/kg	33.7	0.000867	14.8	28
cPAHs	TEQ µg/kg	410	30.8 U	198	900[2]

Notes:
1. Calculated based on 44% of material from pre-construction surface and 56% from cover material, based on assumption that 20 cm of the 45-cm sample is represented by the pre-construction surface and 25 cm is cover material.
2. The 0–45-cm ROD RAL for cPAHs in intertidal areas is 900 µg/kg; the proposed cPAH RAL in the EPA ESD (EPA 2021) is 5,900 µg/kg.
COC: contaminant of concern
cPAH: carcinogenic polycyclic aromatic hydrocarbon
ENR: enhanced natural recovery
ESD: explanation of significant differences
RAL: remedial action level
ROD: Record of Decision
TEQ: toxic equivalent

For PCBs, the analysis was more complex because of the organic carbon (OC)-normalized RAL. The TOC data for the sediment and the cover materials in the two subplots indicate that the 0–45-cm sediment would have TOC greater than 0.5% and less than 3.5%, so the OC-normalized RAL applies. The 0–45-cm RAL would be met in the ENR subplot and the maximum concentration would just exceed the RAL in the ENR/AC subplot (Table 4-3).

Table 4-3.
Estimated Maximum PCB Concentrations in the 45-cm Interval in ENR/AC Pilot Study Intertidal Plot Following Construction

COC	Units	Maximum Pre-construction Conc. (0–10 cm)	Cover Material Conc. (25 cm)	Calculated Max. 0–45 conc.[1]	0–45 cm RAL
PCBs (ENR plot)	mg/kg OC	57	0.037	25	65
PCBs (ENR/AC plot)	mg/kg OC	150	0.003	66	65

Notes:
1. Calculated based on 44% of material from pre-construction surface and 56% from cover material, based on assumption that 20 cm of the 45-cm sample is represented by the pre-construction surface and 25 cm is cover material.
AC: activated carbon
COC: contaminant of concern
ENR: enhanced natural recovery
OC: organic carbon
PCB: polychlorinated biphenyl
RAL: remedial action level

Based on these results, the location with the maximum PCB concentration in the ENR/AC subplot (i.e., LDW-Pilot9a-SS4) will be sampled in the 0–45-cm interval in Phase II to evaluate if this location meets the RAL. Based on the analysis described herein, this is the only location with the potential to exceed the RAL. In addition, as discussed in Section 4.2, Phase II samples will be collected shoreward of these subplots to delineate the extent of RAL exceedances that may remain following the placement of ENR material as part of the pilot study.

4.2 Banks (DQO 11)

DQO 11 involves the characterization of banks located within areas with RAL exceedances. Banks include armored banks, unarmored banks,[18] and vertical bulkheads. The conditions of banks vary.

The following Phase II data gaps have been identified for banks located within areas with RAL exceedances:

- Horizontal extent of RAL exceedances
- Where the preliminary remedial technology assignment requires, the vertical extent of RAL exceedances
- Geotechnical data (see Section 4.4.), topographic data, and other engineering data (see Section 4.5)

[18] As described in the RDWP (Anchor and Windward 2019a) and in Section 2.2 of this document, "unarmored banks" are banks subject to erosion and include vegetated banks and banks with debris or armor in loose, random, or poor condition (discontinuous armor).

The types of data needed for RD vary based on the surface condition of the bank (e.g., armored, unarmored), its characteristics (i.e., slope, vertical bulkhead, or presence of overwater structure), and whether the RAL exceedance in the samples adjacent to the bank is limited to the surface (0–10-cm) or extends to subsurface (0–45 or 0–60-cm) sediments.

Table 4-4 summarizes the various bank types observed in the areas with RAL exceedances (Section 2.2; Appendix E), including example photographs to illustrate each bank type. This table describes the general concepts that were used to identify sediment chemistry and geotechnical data gaps for banks. Bank data collection locations and methods will be presented in the QAPP Addendum.

Table 4-4
Phase II Sampling Concepts for Bank Characterization

Bank Type	Areas with RAL Exceedances[1]	Depth of RAL Exceedance[2]	Need for Bank Chemistry Sampling[3]	Need for Bank Geotechnical Sampling[3]	Example Photos
Armored	7, 12, 30, 31, 32	Surface only	Yes – interstitial sediment	No	 Example Area 12 – Armored
		Subsurface	No	See Note 4	
Unarmored – vegetated	18, 23, 35, 36	Surface only	Yes	No	 Example Area 36 – Unarmored – vegetated
		Subsurface	Yes	Yes	
Unarmored – discontinuous armor	7, 31, 34, 37, and potential area north of RM 3.0	Surface only	Yes	No	 Example Area 31 – Unarmored – discontinuous armor
		Subsurface	Yes	Yes	
Bulkhead	18, 23, 27	Surface only	Depends on uplands coordination – see Sections 4.2.1 and 4.2.2	No	 Example Area 23 – Bulkhead
		Subsurface		See Note 4	 Example Area 32 – Armored with overwater structure
					 Example Area 34 – Unarmored (discontinous armor) with overwater structure

Notes:
1. RAL exceedance area locations are shown on Map 3-3.
2. Surface = 0–10 cm. Intertidal subsurface = 0–45 cm

3. Chemistry and geotechnical sampling details will be site-specific and presented in the QAPP Addendum. Details of horizontal and vertical delineation data gaps for bank areas are presented in Section 4.6.
4. For armored slopes or bulkheads where dredging will occur and the adjacent sample has a subsurface RAL exceedance, geotechnical data will be collected at the toe of the bank or bulkhead. Geotechnical sampling will not be performed within the bank for armored slopes or bulkheads.
QAPP: Quality Assurance Project Plan
RAL: remedial action level
RM: river mile

Based on Phase I PDI observations, there were no observed obstructions, physical access restrictions, or structural condition hazards within the footprint of any structure adjacent to areas with RAL exceedances that would prevent Phase II PDI sampling activities adjacent to or under the existing structures. Sampling adjacent to or under these existing structures will require structure-specific methods and detailed access and potential hazard evaluation in the QAPP Addendum.

4.2.1 Horizontal RAL Exceedance Refinement for Banks

Horizontal RAL exceedance refinement for bank areas below mean higher high water (MHHW) is needed during the Phase II PDI to identify whether RAL exceedances extend into the banks in areas with RAL exceedances. Sampling of these banks will help to refine the horizontal extent of the RAL exceedance areas. The landward limit for potential RAL exceedances is defined by the ROD as MHHW. However, if a dredge or partial dredge and cap remedial action is required on a bank, the engineering design may need to include earthwork above MHHW to the top of bank to ensure a stable shoreline or for climate change resiliency.

For banks within areas with RAL exceedances that abut upland Ecology- or EPA-lead cleanup sites, coordination with Ecology and EPA site managers is being conducted to identify and collect available bank data. This coordination is occurring for the bank areas between the South Park Marina and Terminal 117 (T-117) sites (Exceedance Area 12, Map 3-3) and bank areas at the Boeing Isaacson-Thompson property (Exceedance Areas 18 and 23, Map 3-3), Centerpoint Properties (Exceedance Areas 23, 27, and 30, Map 3-3), and Container Properties (Exceedance Area 31, Map 3-3). Bank data compiled and presented in the Pre-Design Studies DER (Windward 2019) conducted under the third amendment to the Administrative Order on Consent was considered when interpolating horizontal RAL exceedances.

Specifically, horizontal delineation data gaps have been identified for banks within areas with RAL exceedances as follows:

- For unarmored banks, horizontal delineation data gaps are generally:
  - Surface samples (0–10 cm) where the area below the bank includes a surface RAL exceedance
  - Subsurface samples (0–45 cm) where the area below the bank includes a subsurface RAL exceedance
- For armored banks, data from surface samples from the armor layer interstitial sediment (thicker than 10 cm) is considered a data gap for refining horizontal RAL exceedance, when the area below the bank includes a surface RAL exceedance.
- For bulkheaded banks, horizontal RAL exceedance delineation on the bank is not a data gap since the bank is a vertical structure.

Section 4.6 identifies banks with anticipated horizontal RAL exceedance delineation data gaps.

4.2.2 Vertical RAL Exceedance Delineation for Banks

Vertical RAL exceedance delineation is considered a data gap for unarmored banks within areas with RAL exceedances where a dredge or partial dredge and cap remedial action may be needed. For banks with bulkheads or armoring, vertical RAL exceedance delineation data may need to be collected near the toe of bulkheads or armoring to understand the depth of the exceedance. This understanding will support the assessment of the need to perform a dredge or partial dredge and cap remedial action adjacent to the bulkhead or armored bank, or to select an alternate remedial approach to prevent structure or slope instability. Similar to the coordination with upland cleanup sites to obtain existing bank information (as noted in Section 4.2.1), any existing vertical RAL exceedance delineation data will be considered in refining vertical data gap needs.

Specifically, vertical delineation data gaps have been identified for banks within areas with RAL exceedances as follows:

- For unarmored banks, vertical extent delineation (deeper than 0–45 cm) is a data gap where the area below the bank has a subsurface (0–45 cm) RAL exceedance and where dredge or partial dredge and cap are applicable remedial technologies
- For armored banks, because armored banks will not be disturbed, subsurface samples (0–45 cm) to refine horizontal RAL exceedance, and vertical extent delineation information are not data gaps. However, vertical extent delineation adjacent to the armored banks is a data gap for areas with RAL exceedances where dredge is an applicable technology.
- For bulkheaded banks, vertical RAL exceedance delineation on the bank is not a data gap since the bank is a vertical structure. However, vertical extent delineation is a data gap adjacent to the bulkhead for areas with RAL exceedances where dredge is an applicable technology.

Section 4.6 identifies banks with anticipated vertical RAL exceedance delineation data gaps.

4.2.3 Topographic Survey on Banks

Topographic survey data will be collected during Phase II in all banks within areas with RAL exceedances. Section 4.6 identifies these banks. The topographic survey will provide elevation contours, identify the MHHW elevation line, and identify the locations and limits of existing structures and utilities, bank armoring, vegetation, and other features that may affect remedial construction.

Details on topographic surveying methods and locations will be described in an addendum to the survey QAPP (Anchor and Windward 2019b).

4.3 Vertical RAL Exceedance Delineation in Sediment (DQO 12)

To address DQO 12, deep subsurface sediment data (i.e., > 60 cm) are needed in areas with RAL exceedances that may be dredged to delineate the vertical extent of RAL exceedances. Areas with subsurface intervals that do not exceed the RAL based on the design dataset will be considered vertically bounded for the RD.

Vertical RAL exceedance delineation data are considered necessary for areas where dredge or partial dredge and cap are applicable technologies, so that required dredge elevations and caps (where appropriate) can be designed. Vertical RAL exceedance delineation data may also be needed at the boundary between adjacent dredge and ENR areas to inform RD on how to transition between the two remedial technologies. In the navigation channel, vertical delineation will be of sufficient depth to allow for the design of dredge or partial dredge and cap remedies in accordance with ROD Figure 20. For intertidal locations, the logic presented in ROD Figure 19 will be used to develop the vertical delineation strategy. Areas with RAL exceedances that have vertical delineation data gaps are presented in Section 4.6.

4.4 Geotechnical Data (DQO 13)

Geotechnical data are used to assess the dredgeability of sediment, evaluate bearing capacity and settlement of caps, assess stability of existing slopes and structures, assess static and seismic performance of a remedial action, and design stable side slopes for dredge cuts or cap designs. Geotechnical data are a Phase II data gap within areas with RAL exceedances and their associated banks. The type of geotechnical data needed for engineering design is different for in-water areas versus banks, as discussed in this section.

A review effort is underway to obtain existing geotechnical data that may be available for bank and in-water areas relevant to RD. Upland Ecology- and EPA-lead cleanup site managers and LDWG members have been contacted to help identify existing geotechnical information for properties adjacent to banks within areas with RAL exceedances. Available geotechnical data will help inform the types and locations of recommended Phase II PDI geotechnical investigations. A description of existing geotechnical data that have been gathered as well as the proposed geotechnical sampling for areas with RAL exceedances will be provided in the QAPP Addendum.

4.4.1 In-water Geotechnical Data

Geotechnical data will be collected, where geotechnical data do not already exist, for in-water areas. This data will be used to develop representative geotechnical properties, including geologic characterization and sediment strength, to support the following engineering design evaluations:

- Evaluate dredgeability of sediment to be dredged
- Evaluate whether dredge cuts adjacent to existing in-water structures need to be limited or offset to protect the structure
- Assess sediment consolidation and settlement and stability for cap design within in-water areas.
- Develop engineering design criteria for constructing stable dredge cut side slopes.

Geotechnical data collection for in-water areas will not necessarily be tied to specific areas with RAL exceedances unless area-specific engineering design considerations have been identified, such as obtaining geotechnical data in an area adjacent to a bridge structure where dredge is an assigned technology. Rather, in-water geotechnical data collection will be spatially distributed through the upper reach to capture a representative range of geotechnical conditions affecting remedial actions at areas with RAL exceedances. Therefore, Section 4.6 does not identify area-specific geotechnical data gaps for each RAL exceedance area.

4.4.2 Bank Geotechnical Data

Geotechnical data will be collected, where geotechnical data do not already exist, in banks within areas with RAL exceedances. These data will include location-specific geologic characterization, soil and sediment strength, and soil and sediment compressibility data. Geotechnical data will be used during RD to support the following engineering design evaluations:

- Evaluate bank slope stability and stable angles for material removal if dredging or excavation is required in banks.
- Assess sediment consolidation and settlement and stability for cap design in banks.
- Develop engineering design of remedial actions adjacent to existing bank structures, including potential construction offsets to prevent adverse impacts on existing bank structures.
- Evaluate static and seismic performance of remedial actions in banks.

4.5 Other Engineering Data (DQO 14)

This section describes the assessment of Phase II data gaps for other engineering data (DQO 14), including the following:

- Structures
- Vegetation

- Debris
- Waste characterization for disposal
- Sediment thickness over armored banks
- Elutriate testing data

4.5.1 Structures

The design of remedial actions adjacent to structures requires additional structural engineering data that will be collected during the Phase II PDI. Where structures abut or are within areas with RAL exceedances, a more detailed structural inspection will be conducted during the Phase II PDI, including collecting structure dimensions (e.g., pile diameters) and conducting finer-scale visual assessments. These data will be used in concert with geotechnical data (Section 4.4) to support engineering design evaluations of structures during 30% RD.

Table 4-5 provides a list of structures located adjacent to or within areas with RAL exceedances, including the condition assessment ratings assigned to the structures during the Phase I PDI visual inspection. Details on the structures are provided in Appendix F. Detailed evaluation of structure condition and structure dimensions relevant to engineering design evaluations are data gaps that will be addressed during the Phase II PDI. Methods to address the structures data gaps will be described in the QAPP Addendum.

Table 4-5
Structures Adjacent to or Within Areas of RAL Exceedances

RAL Exceedance Area	Adjacent Upland Property Owner	Structures Information			
		Facility ID[1]	Description	Overall Condition Assessment[1]	Structure Safety Concerns for Phase II PDI
5	N/A	ST02	South Park Bridge	Good	None identified
7	King County	ST02	South Park Bridge	Good	None identified
8	N/A	ST02	South Park Bridge	Good	None identified
9	N/A	ST02	South Park Bridge	Good	None identified
10	South Park Marina	ST20	Marina	Fair	None identified
11	South Park Marina	ST20	Marina	Fair	None identified
12	South Park Marina	ST20	Marina	Fair	None identified
13	South Park Marina	ST20	Marina	Fair	None identified
18	Boeing	ST03	Bulkhead	Fair	None identified
23	Boeing, Centerpoint Properties	ST03	Bulkhead	Fair	None identified
27	Centerpoint Properties	ST03	Bulkhead	Fair	None identified

RAL Exceedance Area	Adjacent Upland Property Owner	Structures Information			
		Facility ID[1]	Description	Overall Condition Assessment[1]	Structure Safety Concerns for Phase II PDI
28	National Industrial Holding	ST16	Pier, Dolphins	Fair	None identified
31	Northwest Container Services	ST04	Dolphins	Serious	None identified
32	Boeing	ST05	Pier and Wharf	Poor	None identified
33	Delta Marine Industries	ST12	Pier, Debris Deflector	Good	None identified
34	Boeing	ST07	Wharf	Poor	None identified
37	Boeing	ST07	Timber Groins	Poor	None identified

Notes:
1. See Appendix F for details on the facility identification and condition assessment ratings.
DER: data evaluation report
PDI: Pre-Design Investigation
RAL: remedial action level
N/A: not applicable (RAL exceedance area not adjacent to an upland property)

In addition, details on physical dimensions, conditions, and foundation support for outfalls in areas with RAL exceedances are identified data gaps that will be described in the QAPP Addendum and investigated further during the Phase II PDI. Outfall observations from the Phase I bank and structures investigations are summarized in Appendix F.

4.5.2 Vegetation

As part of the bank visual inspection conducted in Phase I (Section 2.2), information was collected regarding the presence of vegetation along the shoreline. More detailed vegetation or habitat information may be needed once the extent of banks requiring remedial action (including disturbance of vegetation) is more clearly understood (i.e., during 30% RD). Thus, location-specific, detailed vegetation or habitat assessments to assist in designing potential mitigation may be identified as a Phase III data need during 30% RD. A biological assessment will be prepared during 90% RD, as noted in RDWP Section 6.2.3 (Anchor and Windward 2019a).

4.5.3 Debris

In areas with RAL exceedances, large surface debris may need to be removed and disposed of during remedial construction. The photo documentation conducted during the Phase I bank visual inspection provides useful information regarding the general locations of shoreline debris above the MLLW elevation. Specific location data (i.e., horizontal coordinates) for large debris above the MLLW elevation will be collected during the topographic survey to be conducted during the Phase II PDI.

The forthcoming addendum to the Survey QAPP will identify methods for collecting visible debris location information.

Identification of large surface debris below MLLW is not considered a data gap for the Phase II PDI. Multibeam bathymetric data collected during the Phase I PDI (Section 2.4) are of sufficient resolution to allow for identification and location of large surface debris for 30% RD in areas where remedial action will occur.

4.5.4 Waste Characterization for Disposal

Disposal facilities typically require waste characterization data to compare their facility permit standards with the waste profile (i.e., bulk chemistry) of sediment to be disposed of at the facility. Waste characterization for materials to be dredged is considered a data gap. Methods to address this data gap will be described in the QAPP Addendum.

Waste characterization will be performed after 30% RD to provide contaminant concentrations representative of those in the waste material. The characterization may be based on mathematical compositing of Phase II core results, or on composite samples created from Phase II archive samples located within dredge areas. This characterization must be conducted after 30% RD, which will occur after dredging depths have been determined, in order to identify the representative characteristics of the material from the design dredge prisms.

4.5.5 Sediment Thickness over Armored Banks

For armored banks, potential remedial actions will need to be designed considering the location of the armor toe and the thickness of sediment above the armor layer. Sediment thickness above engineered armor is a Phase II data gap. Section 4.6 presents the areas with RAL exceedances where data on sediment thickness over armored banks will be collected. Methods to address this data gap and the specific locations for data collection will be described in the QAPP Addendum.

4.5.6 Elutriate Testing

Dredge elutriate testing (DRET) (DiGiano et al. 1995) is a method to estimate dissolved contaminant concentrations that may be released to surrounding water from dredged sediment during dredging for comparison with acute water quality criteria in the vicinity of dredging operations. However, DRET tests performed on even highly contaminated sediments throughout Puget Sound (e.g., Hylebos Waterway in Commencement Bay) have very rarely approached acute water quality criteria (HCC 1999). Moreover, detailed water quality monitoring performed at other sites throughout the U.S. have demonstrated that DRET does not accurately predict dissolved contaminant concentrations released during dredging operations (Vicinie et al. 2011). In addition, DRET has not been used for RD of EAAs. For these reasons, DRET is not proposed for the upper reach.

In place of DRET, contaminant partitioning calculations have been used to compare expected dissolved contaminant concentrations to acute surface water criteria at the point of compliance during dredging, similar to the calculation procedures outlined in the *Sediment Evaluation Framework for the Pacific Northwest* (RSET 2016). The Sediment Evaluation Framework report developed elutriate test triggers based on general partitioning assumptions that can be used to approximate water quality impacts at the point of dredging (Sediment Evaluation Framework report Table 9-2); additional calculations can be used to estimate concentrations at the water quality point of compliance.

For example, DRET tests were performed for the East Waterway Phase 1 Removal Action (located at the mouth of the LDW), which was conducted from 2003 to 2004 as a non-time-critical removal action under EPA oversight. The results of the East Waterway Phase 1 Removal Action DRET analysis showed that sediment concentrations below 45,000 µg/kg total PCBs would not warrant elutriate testing to evaluate compliance with acute water quality criteria for total PCBs in WAC 173-201A (Anchor and Windward 2003); this concentration is in the same order of magnitude as the partitioning-derived concentration of 23,608 µg/kg in Sediment Evaluation Framework report Table 9-2. Other contaminants evaluated with DRET were also both much lower than acute water quality criteria and reasonably well estimated by partitioning estimates.

4.6 Summary of Data Gaps for Each Area with RAL Exceedance

In order to set the stage for the QAPP Addendum, which will provide details regarding sample locations, intervals, analytes, and other considerations, this section provides a summary of area-specific data gaps. This summary is preliminary and subject to change in the QAPP Addendum.

Horizontal RAL exceedance delineation was the primary purpose of Phase I. During Phase II, horizontal delineation data gaps specific to each RAL exceedance area will be addressed. To facilitate refinements of delineated areas, five rationale categories were developed to provide a framework for Phase II planning (Table 4-6). To enable review of this table, Maps 4-1a through 4-1e overlay the areas with RAL exceedances with the design dataset sampling locations and locations where a COC exceeds a RAL.

Table 4-6
Rationale for Additional Horizontal RAL Exceedance Delineation Data in Phase II Summarized by Area and Category

Data Gap	Area(s) with RAL Exceedances
Data in buffer area north of RM 3	1
Data around interpolated boundaries where needed to supplement existing design dataset	1, 2, 3, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18, 20, 23, 27, 28, 30, 31, 32, 34, 35, 36, 37

Data Gap	Area(s) with RAL Exceedances
Interpolated concentrations across RAL application boundaries	4, 14, 19, 22, 26, 29, 33
Re-occupation for potential toxicity testing	21, 34, 35
Bank horizontal RAL exceedance delineation	Potential area north of RM 3.0, 7, 12, 18, 23, 30, 31, 32, 34, 35, 36, 37

Notes:
RAL: remedial action level
RM: river mile

Table 4-7 presents a summary of data gaps for each of the 37 areas with RAL exceedances. Table 4-7 is organized as follows:

- Columns 1 through 3 provide the RAL exceedance area number, the approximate river mile of the area, and the recovery category/categories within the area.
- Columns 4 and 5 summarize the types of RAL exceedances for the area.
- Columns 6 through 8 describe whether the area includes a bank (and if so, the bank type), a structure (and if so, the structure type), and the preliminary technology assignment option(s) for the area based on the preliminary technology assignment logic (described in detail in Appendix K).
- Columns 9 through 16 summarize Phase II data gaps for each area with RAL exceedances, as follows:
  - Columns 9 through 11 describe data gaps for in-water areas.
  - Columns 12 through 16 describe data gaps for banks.
- Column 17 provides preliminary notes on horizontal delineation and other considerations for each area.

Sampling efforts to fill the data gaps identified in Table 4-7 will be further described in the QAPP Addendum.

Table 4-7
RAL Exceedance Areas, Preliminary Technology Assignments Options, and Phase II Data Gaps

[1] Area	[2] RM	[3] Recovery Category (Intertidal, Subtidal, or Shoal Area)	[4] Surface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[5] Subsurface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[6] Bank Type if Present	[7] Structures Present	[8] Preliminary Technology Assignment Options (see Appendix K)	Data Gaps for Phase II Sampling and Analysis (yes = data needed / no = no data needs/ or N/A)							[17] Preliminary Horizontal Delineation and Other Considerations
								Data Gaps to Refine the Areas with Sediment RAL Exceedances[1]			Data Gaps to Evaluate Bank Areas				
								Horizontal Extent of RAL Exceedance			Horizontal Extent of RAL Exceedance				
								[9] Surface	[10] Subsurface	[11] Vertical Extent	[12] Surface	[13] Subsurface	[14] Vertical Extent	[15] Geotech	[16] Topography or Other Engineering Information
N of upper reach	2.9W	3 (intertidal) 1 (subtidal)	Yes	No data	Unarmored – discontinuous	No structure	ENR, dredge, or partial dredge and cap	Yes	Yes	No	No	No	No	No	Assess area within 100 ft N of boundary to determine if any action is needed directly N of RM 3.0 (i.e., RAL exceedance area extends across boundary)
1	3.0	1 (subtidal)	No (but PCB EF was 1.0)	Yes	No bank	No structure	Dredge or partial dredge and cap	Yes	Yes (0–45 and 0–60 cm)	Yes	N/A				Bound surface and subsurface to the N, S, and W
2	3.05	1 (subtidal)	No	Yes	No bank	No structure	Dredge or partial dredge and cap	No	Yes (0–60 cm)	Yes	N/A				Bound subsurface to the N, S ,and W
3	3.1	1 (subtidal)	No	Yes	No bank	No structure	Dredge or partial dredge and cap	No	Yes (0–60 cm)	Yes	N/A				Bound subsurface to the N, S, and W
4	3.15	1 (subtidal)	No	No	No bank	No structure	Need to confirm if exceedance; if so, dredge or partial dredge and cap	No	Yes (0–60 cm)	No	N/A				Collect subsurface sample in recovery category 1 to confirm interpolation Area exists based on interpolation (PCBs in IT120 with 24 mg/kg OC and SC121 with 18 mg/kg OC) extending into subtidal recovery category 1 area with RAL of 12 mg/kg OC)
5	3.1–3.3	1 (subtidal)	Yes	Yes	No bank	Overwater – Bridge on S end	Dredge or partial dredge and cap; potentially cap in deeper area near South Park Bridge,	No	Yes (0–60 cm)	Yes	N/A				Bound subsurface to the N and S under bridge
6	3.23W	3 (intertidal and subtidal)	Yes	No	No bank	No structure	ENR	Yes	No	No	N/A				Bound surface interval to N
7	3.3W	3 (intertidal and subtidal)	Yes	No	Unarmored, discontinuous; Armored	Overwater - Bridge	ENR, dredge, partial dredge and cap, or cap/armored cap	Yes	Yes (0–45 and 0–60 cm)	Yes	Yes	Yes	Yes	See Note 2	Topography, Sediment thickness over armor	Bound to the N, S, and W
8	3.35	1 (subtidal)	No	Yes	No bank	Overwater – Bridge on N end	Dredge or partial dredge and cap	No	Yes (0–60 cm)	Yes	N/A				Bound subsurface to the N under bridge and to the S
9	3.35	shoal	No	Yes	No bank	Overwater – Bridge on N end	Dredge or partial dredge and cap	No	Yes (-15 to -17 ft MLLW)	Yes	N/A				Bound mercury and fluoranthene in subsurface to N and S

[1] Area	[2] RM	[3] Recovery Category (Intertidal, Subtidal, or Shoal Area)	[4] Surface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[5] Subsurface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[6] Bank Type if Present	[7] Structures Present	[8] Preliminary Technology Assignment Options (see Appendix K)	Data Gaps for Phase II Sampling and Analysis (yes = data needed / no = no data needs/ or N/A)								[17] Preliminary Horizontal Delineation and Other Considerations
								Data Gaps to Refine the Areas with Sediment RAL Exceedances[1]			Data Gaps to Evaluate Bank Areas					
								Horizontal Extent of RAL Exceedance			Horizontal Extent of RAL Exceedance					
								[9] Surface	[10] Subsurface	[11] Vertical Extent	[12] Surface	[13] Subsurface	[14] Vertical Extent	[15] Geotech	[16] Topography or Other Engineering Information	
10	3.4	shoal	Yes	No	No bank	Marina	Dredge or partial dredge and cap	Yes	No	No	N/A					Bound surface to the W
11	3.4	shoal	No	Yes	No bank	Marina	Confirm and dredge or partial dredge and cap if necessary	No	Yes (-15 to -17 ft MLLW)	Yes	N/A					Re-sample subsurface at LDW13 in -15 to -17 ft MLLW and delineate vertical
12	3.5W	3 (intertidal and subtidal)	Yes	No data within area but no RAL exceedances in 0-60 cm in surrounding PDI samples	Armored	Marina	ENR, dredge, or partial dredge and cap	No	No	Yes	Yes – interstitial sediment in armor	No	No	No	Topography; Sediment thickness over armor	Collect vertical extent data and bound horizontal in bank
13	3.5	shoal	No	Yes	No bank	Marina	Confirm and dredge or partial dredge and cap if necessary	No	Yes (-15 to -17 ft MLLW)	Yes	N/A					Re-sample subsurface at LDW14 in -15 to -17 ft MLLW and delineate vertical
14	3.55	shoal	No	No	No bank	No structure	Confirm and dredge or partial dredge and cap if necessary	No	Yes	Yes	N/A					Sample in shoal area to confirm interpolation Area exists based on interpolation (PCBs in core T117-SE-15-SC [16.5 mg/kg OC] extending into shoal area with RAL of 12 mg/kg OC)
15	3.6	1 (subtidal)	No data	Yes	No bank	No structure	Dredge or partial dredge and cap	Yes	Yes (0–60 cm)	Yes	N/A					Bound surface and subsurface to the N
16	3.65	1 (subtidal) and shoal	Yes	Yes	No bank	No structure	Dredge or partial dredge and cap	No	Yes (0–60 cm)	Yes	N/A					Bound subsurface to N, S, and E
17	3.7	1 (subtidal) and shoal	Yes	No	No bank	No structure	Dredge or partial dredge and cap	Yes	Yes	Yes, if subsurface hit	N/A					Bound surface to the NW
18	3.7–3.8E	2 (intertidal and subtidal) 1 (subtidal)	Yes	No (limited data)	Unarmored – vegetated; Bulkhead	Bulkhead	ENR, dredge, or partial dredge and cap	Yes	Yes (0–45 and 0–60 cm)	Yes	Yes	Yes	Yes	See Note 2	Topography; Structure inspection	Collect surface and subsurface bounding data to the W and S and bank data to the E Note pre-PDI subsurface data did not include RAL intervals
19	3.75W	shoal	No	No	No bank	No structure	Dredge or partial dredge and cap	No	Yes (0–45 cm)	No	N/A					Sample in subsurface to confirm interpolation Area exists based on interpolation (PCBs in IT221 [486 µg/kg dw] extending into shoal area with RAL of 12 mg/kg OC)

[1] Area	[2] RM	[3] Recovery Category (Intertidal, Subtidal, or Shoal Area)	[4] Surface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[5] Subsurface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[6] Bank Type if Present	[7] Structures Present	[8] Preliminary Technology Assignment Options (see Appendix K)	Data Gaps for Phase II Sampling and Analysis (yes = data needed / no = no data needs/ or N/A)								[17] Preliminary Horizontal Delineation and Other Considerations
								Data Gaps to Refine the Areas with Sediment RAL Exceedances[1]			Data Gaps to Evaluate Bank Areas					
								Horizontal Extent of RAL Exceedance			Horizontal Extent of RAL Exceedance					
								[9] Surface	[10] Subsurface	[11] Vertical Extent	[12] Surface	[13] Subsurface	[14] Vertical Extent	[15] Geotech	[16] Topography or Other Engineering Information	
20	3.8W	3 (intertidal and subtidal) and shoal	No	Yes	Habitat restoration recently built on bank above a toe elevation ranging from +4 to +8 MLLW	No structure	Dredge or partial dredge and cap	No	Yes	Yes	No	No	No	No	No	Bound subsurface to the E, W, and S; coordinate with Port habitat restoration
21	3.8W	3 (intertidal)	Yes	No	Habitat restoration recently built on bank above a toe elevation ranging from +4 to +8 MLLW	No structure	ENR if needed	Yes, to reoccupy if toxicity testing is needed	No	No	No	No	No	No	No	Discuss isolated SMS exceedance; if necessary, re-occupy and toxicity test if appropriate; coordinate with Duwamish River People's Park and Shoreline Habitat project
22	3.8	shoal	No	No	No bank	No structure	Confirm, and if so dredge or partial dredge and cap	No	Yes (0–60 cm)	No	N/A					Bound subsurface to confirm interpolation Area exists based on interpolation (PCBs in IT232 [15.1 mg/kg OC] extending into shoal area with RAL of 12 mg/kg OC)
23	3.83E	2 (intertidal and subtidal) and 1 (subtidal)	Yes	No	Unarmored – vegetated; Bulkhead	Bulkhead	ENR, dredge or partial dredge and cap	Yes	Yes (0–45 cm and 0–60 cm)	Yes	Yes	Yes	Yes	See Note 2	Topography; Structure inspection; Debris	Area is in between ENR/AC subplots; address banks adjacent to ENR/AC subplots (RM 3.83-3.94E); bound surface and subsurface (0–60 cm) to the W; sample 0-45 cm to the N
24	3.88	1 (subtidal) and shoal	No	Yes	No bank	No structure	Dredge or partial dredge and cap	No	Yes (-15 to -17 ft MLLW)	Yes	N/A					Re-sample subsurface at LDW17 in -15 to -17 ft MLLW and delineate vertical
25	3.9W	3 (intertidal)	Yes	No (in bounding samples)	Habitat restoration recently built on bank above a toe elevation ranging from +4 to +8 MLLW	No structure	ENR	No	No	No	No	No	No	No	No	No vertical needed in sediment since ENR; coordinate with Duwamish River People's Park and Shoreline Habitat project
26	3.85	1 (subtidal)	No	No	No bank	No structure	Dredge or partial dredge/cap	No	Yes (0-60 cm)	Yes, if confirmed	N/A					Sample in subtidal to confirm interpolation Area exists based on interpolation (PCBs in IT257 [202 mg/kg OC] extending N into shoal area with RAL of 12 mg/kg OC)

[1] Area	[2] RM	[3] Recovery Category (Intertidal, Subtidal, or Shoal Area)	[4] Surface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[5] Subsurface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[6] Bank Type if Present	[7] Structures Present	[8] Preliminary Technology Assignment Options (see Appendix K)	Data Gaps for Phase II Sampling and Analysis (yes = data needed / no = no data needs/ or N/A)							[17] Preliminary Horizontal Delineation and Other Considerations
								Data Gaps to Refine the Areas with Sediment RAL Exceedances[1]			Data Gaps to Evaluate Bank Areas				
								Horizontal Extent of RAL Exceedance			Horizontal Extent of RAL Exceedance				
								[9] Surface	[10] Subsurface	[11] Vertical Extent	[12] Surface	[13] Subsurface	[14] Vertical Extent	[15] Geotech	[16] Topography or Other Engineering Information
27	3.95E	2 (intertidal) and 1 (subtidal)	Yes	Yes	Bulkhead	Bulkhead	ENR, dredge or partial dredge and cap	Yes	Yes	Yes	Not applicable			See Note 2	Structure inspection	Bound surface and subsurface to the W in the subtidal; assume horizontal extent to the E is defined by the bulkhead along the shoreline
28	3.95W	1 (intertidal and subtidal)	No	Yes	No bank	Dolphin, pier to the S	Dredge or partial dredge and cap	No	Yes (0-45 cm)	Yes	N/A					Bound subsurface to the S and E
29	3.98	1 (subtidal)	No	No	No bank	No structure	Dredge or partial dredge and cap	No	Yes (0-60 cm)	No	N/A					Sample in subtidal to confirm interpolation Area exists based on interpolation (PCBs in IT260 [17.6 mg/kg OC] extending into RC 1 area with RAL of 12 mg/kg OC)
30	4.0E	2 (intertidal and subtidal)	Yes	No	Armored	No structure	ENR	Yes	No	No	Yes – interstitial sediments in armor	No	No	No	Topography; Sediment thickness over armor	Bound to W and interstitial sediment to the E
31	4.0–4.1E	2 and 3 (intertidal)	Yes	Yes	Unarmored – discontinuous; Armored	Remnant piles and dolphins	ENR, dredge, or partial dredge and cap	Yes	Yes (0–45 cm)	Yes	Yes	Yes	Yes	See Note 2	Topography; Sediment thickness over armor	Bound surface and subsurface to the W, surface to the S, and banks to the E
32	4.2E	1 (intertidal and subtidal)	No	Yes	Armored	Overwater pier and wharf	Dredge or partial dredge and cap	No	Yes	Yes	No	No	No	See Note 2	Topography; Sediment thickness over armor; Structure inspection	Slip 6 –Bound to the E and NW Note pre-PDI cPAH TEQs are less than proposed cPAH RALs in the ESD
33	4.25W	1 (intertidal and subtidal)	No	No	No bank	Pier, debris deflector	Dredge or partial dredge and cap if necessary	No	Yes (0–45 cm and archive 0–60 cm)	No	N/A					Analyze subsurface to E to confirm interpolation Area exists based on interpolation (PCBs in IT359 [15.6 mg/kg OC] extending into RC 1 area with RAL of 12 mg/kg OC)
34	4.6E	1 (intertidal and subtidal)	Yes	Yes	Unarmored – discontinuous	Nearby wharf	Dredge, partial dredge and cap, or cap/armored cap if necessary	Yes	Yes (0–45 and/or 0–60 cm)	Yes	Yes	Yes	Yes	See Note 2	Topography; Structure inspection	Re-occupy and potentially toxicity test, bound to the W, E, and S
35	4.7W	3 (intertidal)	Yes	No	Unarmored - vegetated	No structure	ENR	Yes	No	Yes, if needed	Yes	No	No	No	Topography	Re-occupy to toxicity test and bound to N, S, W, and E Note cPAH TEQ is less than proposed cPAH RAL in the ESD
36	4.75W	1 and 3 (intertidal)	Yes	No	Unarmored - vegetated	No structure	ENR, dredge, or partial dredge and cap	Yes	Yes	Yes	Yes	Yes	Yes	See Note 2	Topography	Sample surface sediment and bank to bound bank sample (+3–4 ft MLLW) to the N, S, W , and E and the 2005 exceedance to the S

[1] Area	[2] RM	[3] Recovery Category (Intertidal, Subtidal, or Shoal Area)	[4] Surface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[5] Subsurface Sediment RAL Exceedance (see Maps 4-1a–4-1i)	[6] Bank Type if Present	[7] Structures Present	[8] Preliminary Technology Assignment Options (see Appendix K)	Data Gaps for Phase II Sampling and Analysis (yes = data needed / no = no data needs/ or N/A)							[17] Preliminary Horizontal Delineation and Other Considerations
								Data Gaps to Refine the Areas with Sediment RAL Exceedances[1]			Data Gaps to Evaluate Bank Areas				
								Horizontal Extent of RAL Exceedance			Horizontal Extent of RAL Exceedance				
								[9] Surface	[10] Subsurface	[11] Vertical Extent	[12] Surface	[13] Subsurface	[14] Vertical Extent	[15] Geotech	[16] Topography or Other Engineering Information
37	4.9E	2 (intertidal and subtidal)	Yes	No	Unarmored - discontinuous	Timber groins	ENR, dredge, or partial dredge and cap	Yes	No	Yes	Yes	No	Yes	See Note 2	Topography; Structure Inspection	Bound surface to the W and E, including collecting a surface sample on cap (bounding 416). Norfolk cap is sand – no samples needed vertically

Notes:
1. Each individual area with RAL exceedances does not necessarily require a geotechnical sample. Representative geotechnical samples will be collected within subtidal and intertidal areas.
2. Geotechnical sampling may be needed in specific bank areas after review of existing geotechnical data, and geotechnical sampling locations and methods will be identified in the QAPP Addendum.

[1]: Table column number, as described in text
AC: activated carbon
BBP: butyl benzyl phthalate
cPAH: carcinogenic polycyclic aromatic hydrocarbon
EAA: early action area
Ecology: Washington State Department of Ecology
EF: exceedance factor
ENR: enhanced natural recovery
EPA: US Environmental Protection Agency
ESD: explanation of significant differences
LDW: Lower Duwamish Waterway
MLLW: mean lower low water
N/A: not applicable
OC: organic carbon
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
QAPP: Quality Assurance Project Plan
RAL: remedial action level
RM: river mile
ROD: Record of Decision
SMS: Washington State Sediment Management Standards
T-117: Terminal 117
TEQ: toxic equivalent
USACE: US Army Corps of Engineers

5 Next Steps

The data gaps identified in this document will be addressed through the Phase II PDI. Specific details regarding this data collection, including chemistry, geotechnical, and other engineering information, will be described in the forthcoming QAPP Addendum or the addendum to the Survey QAPP.

After the addenda are approved by EPA, LDWG will conduct the Phase II PDI. The design dataset will be supplemented with the Phase II data and used in RD. Prior to starting work on the Phase II DER, LDWG will discuss the data interpolation method and its parameterization with EPA to determine a final approach to be used for the Phase II DER and the RD.

As shown in Figure 1, Phase II PDI data collection is planned for summer 2021. The 30% RD is anticipated to begin in early 2022 as the Phase II PDI data become available, as described in the RDWP (Anchor and Windward 2019a). The need for a Phase III PDI will be determined after LDWG receives EPA comments on 30% RD. If needed, this phase is anticipated to take place between November 2022 and March 2023, per the project schedule.

6 References

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Appendix A
Location Coordinates, Sediment Chemistry Field Notes and Forms, Chain of Custody Forms, and Photographs

Appendix B
Sediment Chemistry Laboratory and Validation Reports

Appendix C
Phase I Data File

Appendix D
Relationship Between Surface and Subsurface Contaminant of Concern Concentrations

Appendix E
Bank Visual Inspection Detailed Observations, Photographs, and Videos

Appendix F
Structures Visual Inspection Forms

Appendix G
2020 Bathymetric Survey Data Report

Appendix H
Data Rules

Appendix I
Recovery Categories Assessment

Appendix J
Interpolation Methods for Delineating Areas with RAL Exceedances

Appendix K
Remedial Technology Assignment Options for Areas with RAL Exceedances